V-series Smartmodem 2400™

User's Guide

Hayes®

V-series

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The V-series Advantage

The V-series Smartmodem 2400 enhances telecommunications by offering increased throughput, feature negotiation, flow-control, adaptive compression, and error-control for interactive communications and data transfers, all while maintaining compatibility with other Hayes modems.

Increased Throughput

The V-series Smartmodem 2400 extends your system's capability to send and receive information. The modem adjusts its rate during initial handshake to enable connections at the highest speed supported by the remote modem—300, 1200, or 2400 bps. All data rates offered by earlier Hayes modems are supported in both originate and answer modes. In V-series-to-V-series modem communications using error-control mode, effective throughput of the data can be significantly higher than that with standard connections because of adaptive compression.

Feature Negotiation

The V-series Smartmodem 2400 automatically negotiates the best possible connection with the remote modem, distinguishing between V-series modems and other Hayes (or 100% Hayes compatible) modems. Options allow you to specify guidelines for the modem to follow when setting up communications with remote systems.

Error Control

Hayes V-series modems ensure accurate communication by utilizing an ARQ protocol that automatically requests retransmission of any data that might have been corrupted as it was transmitted across the link. The V-series Smartmodem 2400 achieves this error-control link by using a protocol based on CCITT LAP-B (Link Access Protocol—Balanced) at 1200 bps and 2400 bps.

Data Flow-Control

Because error-control involves re-transmitting data not correctly received, data sent from the DTE to the modem may not be immediately transmitted. To ensure no data is lost because of overfilling buffers, the V-series modems offer flow-control options. If flow-control is not enabled on the link between the modem and the DTE, data can be lost because the modem's buffers cannot accept any more data from the attached data terminal. The V-series Smartmodem 2400 supports several methods of regulating the flow of data to and from the DTE: RTS/CTS, Transparent XON/XOFF, and XON/XOFF. Flow-control can also be disabled if the application does not require its use.

Adaptive Compression

Hayes has developed a technique for coding data that reduces the number of bits required for transmission. The gain in bits-to-data ratio can actually increase the throughput – when transmitting files or when performing interactive communication. This adaptive compression method is superior to other methods in that it adjusts to the type of data being transmitted. Adaptive compression is automatically enabled when the modem is operating in error-control mode; no user interaction or preparation of data is required at either end of the connection.

Using this Guide Effectively

After the modem has been installed according to the instructions in the **Getting Started** booklet, use the instructions provided by this manual to configure the modem and begin to communicate with remote systems.

Communication Environment

The commands described in this manual are used primarily when the modem is connected to a terminal or when the communication environment requires that you issue instructions directly to the modem. If the modem is connected to a computer, you must use communication software, at least an emulation program, to configure and operate the modem. Without software of some kind, the computer will not convey input from the keyboard to the modem. Hayes' Smartcom III™ was designed to complement the V-series Smartmodem 2400's advanced features. Smartcom III performs the setup and issues the necessary commands for the modem's asynchronous communications; you simply make menu selections.

If you use other commercial software or a terminal program, the software must support a local flow-control method, provide adequate throughput, and support the commands added for V-series functions (e.g., &Q5—Error-Control Mode). By issuing the commands through such a program or by incorporating them in a program of your own design, you can take advantage of all the features offered by the V-series Smartmodem 2400. If you will be using Smartcom III, you do not need to proceed with this manual; after you have installed the modem according to the instructions in the **Getting Started** booklet, you can go on to the **Smartcom III User's Guide**.

Asynchronous/Synchronous Communication

In addition to asynchronous communication, the data transmission method for PC-to-PC communication, the modem also supports synchronous communication, the data transmission method commonly used when connecting a terminal or a computer to a mainframe. Chapter 6, **Data Transmission Options**, explains how the modem can be used for synchronous communication.

AT Commands and Operating States

1

This chapter explains the modem's two operating states, how to move between them, and the command syntax used to send configuration and communication instructions to the modem. When the modem is on, it is in one of two operating states, command or on-line. In on-line state, the modem communicates with a remote system. In the command state (available in asynchronous mode only), the modem accepts instructions in the form of AT Commands.

The descriptions of the commands in this and subsequent chapters assume you are running software that permits you to place the modem in the asynchronous command state and issue commands directly from the keyboard, or that you have connected the modem to a terminal. With the information provided in this chapter, you will be able to proceed to Chapter 2, **Connecting with a Remote System**, for instructions on placing and answering calls.

AT Commands

The V-series Smartmodem 2400 is configured and controlled using the Hayes Standard AT Command Set and an additional group of commands that enable V-series functions. These instructions can be issued directly from the keyboard, or may be sent to the modem through software. The modem returns result codes to indicate the responses to the instructions it receives.

Command Syntax

Instructions to the modem are issued according to a simple command syntax. All commands are prefixed by AT and followed by a carriage return character that executes them.

Automatic Rate and Parity Selection – AT

Instructions are referred to as "AT commands" because they are all preceded by the **AT** prefix that "gets the modem's attention." The modem examines this prefix and automatically determines the transmission rate of the local data terminal, character length, and parity setting of your data terminal equipment. (For more information, see Chapter 6, **Data Transmission Options**.)

Both letters of the **AT** prefix must be entered in upper or lower case (at or AT). The modem will not recognize an upper case "A" and a lower case "t " (At) or the reverse combination (aT).

Command Formats

The modem recognizes the two formats of the Hayes Standard AT Command Set and the additional commands required to enable the V-series functions.

Smartmodem 300™, Smartmodem 1200™, and Smartmodem 1200B™ support the single-letter commands. For example, the **L** command controls the modem's speaker level.

The Smartmodem 2400™ and the Smartmodem 2400B™ introduced advanced features; commands for the expanded capabilities combine an ampersand (**&**) with a single letter. For example, **&F** retrieves the factory configuration.

The V-series Smartmodem 2400 recognizes the commands in both the single-letter and the ampersand/letter formats. In addition to the descriptions throughout this manual, all AT commands used to configure and control the modem are described in Appendix A, **Hayes Standard AT Command Set**.

Parameters

Most AT commands have selectable, numeric parameters. For example, **E0** turns off command state character echo; **E1** turns it on. In this case the parameter serves as a toggle. A parameter may also select one of several configuration options. The **X** command (result code selection) has five parameter options (**X0**, **X1**, **X2**, **X3**, and **X4**).

A parameter can also be used as a pointer; in the command **&Z1=5552368**, the "**1**" points to a location in which the telephone number "**5552368**" is to be stored.

Values

Values are variables that can be assigned to parameters that are used as pointers (e.g., **Sr** commands, where "**r**" represents an internal memory location—S-Register). To assign a value, place the parameter after the command to point to the location, add an equal sign, and follow it with the desired value. For example, the command **S0=3**, uses a parameter to point to S-Register memory location "**0**" and assigns the value "**3**" as the number of rings to occur before the modem answers an incoming call.

Note: When the modem receives a command without a parameter or a value, **0** is assumed. For example, both **E** and **E0** turn command state character echo off.

Carriage Return Character – <CR>

The carriage return key executes the command(s) in the modem's buffer. The actual key used depends upon the computer or terminal to which the modem is connected. For example, this function may be provided by the Enter key, or by the Return key. In this manual, the key function is represented with <**CR**>.

Command Line

A command line can contain as many as 255 characters and may be used to send one or more commands to the modem. Command lines are preceded with the **AT** prefix, and terminated with the <**CR**>. The **AT** prefix, and the <**CR**> at the end of the command line are not counted in this total. Spaces, however, are significant and are counted as part of the 255 characters in the command line.

The escape sequence (**+++**) and the repeat previous command (**A/**) are the only exceptions to the command line structure; they are sent without the **AT** prefix and the <**CR**>, and must appear on a line by themselves.

Commands can generally be combined in a single line, however, some commands must be entered on a line by themselves as they prevent other commands on the same line from being processed.

Note: When **AT** commands are discussed in this user's guide, only the command with the parameter and/or value is referenced; the **AT** prefix and the <**CR**> are included only when illustrating a complete command line. For example, the answer command is referred to as **A**. When a procedure includes instructions for an operation, the complete command line (e.g., **ATA**<**CR**>) is given.

Command Buffer

The command buffer stores a single command line. If a line exceeding the 255 character limit is sent, the modem returns the **ERROR** result code.

The command buffer is cleared when:

- the command line is backspaced over
- a new command is issued
- the modem is powered down
- a soft reset is performed (**Z** command or on-to-off transition of DTR if modem programmed to respond to this signal)

Note: Commands are neither loaded into the command buffer nor executed while the phone is ringing (indicated by the **RING** result code). However, commands are recognized and executed between rings.

Editing the Command Line

To change a command line prior to entering a <**CR**>, simply remove as much of the line as is necessary with the backspace key, and type in the changes. The **AT** prefix placed on the command line cannot be deleted.

Note: Rapidly repeated or auto-repeat backspaces may not work properly. The combination of characters comprising the backspace function requires additional processing time. To avoid miscommunication from the computer to the modem, pause between each keystroke when entering multiple backspaces.

Repeating the Previous Command – A/

The repeat previous command instructs the modem to re-execute the command stored in the command buffer. **A/** must be issued on a line by itself. Neither the **AT** prefix nor the <**CR**> is used with this command.

Result Codes

The modem provides responses to commands in the form of result codes. The form and set of result codes returned may be selected with AT commands. Unless disabled with the **Q1** command, a result code is displayed after a command is entered. For further information, refer to Chapter 5, **Interface Parameters**.

Operating States

Except for brief transitional periods (when the modem is being powered up) the modem is in one of two operating states: command or on-line. Depending on the current transmission mode – synchronous or asynchronous – one or both of these states can be selected. In asynchronous mode, both states can be accessed. In synchronous mode, only the on-line state is available. For this reason, the modem must be configured from an asynchronous terminal, even if the modem will be used synchronously. For a diagram illustrating the modem's operating states in various communication modes, see Chapter 6, **Data Transmission Options**.

Command State

When power is applied to the modem, it recalls a stored user profile from nonvolatile memory and enters the asynchronous command state (unless configured for synchronous operation; see Chapter 6, **Data Transmission Options**). From the command state, calls can be originated or answered, S-Registers read and set, and other instructions issued. Except in the error-control mode, data is neither transmitted nor received while the modem is in the command state. Instructions can be issued only when the modem is in this state.

The modem remains in or enters the command state when:

- the modem is powered up (resets modem)
- the reset command (**Z**) is issued
- the factory configuration is retrieved (**&F** command)
- no carrier is detected while originating or answering a call
- a carrier signal from the remote modem is lost
- the **&D1**, **&D2**, or **&D3** option is selected and the modem detects an on-to-off transition on the DTR circuit
- a semicolon (;) is entered at the end of the dial (D) command to return the modem to the command state
- the escape sequence (**+++**) is entered while the modem is on-line

On-line State

The modem goes on-line after making a connection with the remote system. When on-line, data can be transmitted and received.

The modem attempts to go on-line in the following situations:

When originating a call,

- dial command (**D**) is issued
- on-line command (**O0**) is issued

— or—

When answering a call,

- answer command (**A**) is issued
- modem ring count (value of Register S1) equals the number of rings to answer on (value of Register S0)
- dial command (**D. . . R**) is issued with Reverse dial modifier at the end of the dial string, allowing modem to originate a call in answer mode (to dial an originate-only modem)

Moving Between Operating States

When communicating with a remote system, the modem can be switched between the command and on-line states with the escape sequence (or transition of DTR if the **&D1** option is selected) and the on-line command (**O0**). This provides the flexibility to adjust settings while maintaining the connection with the remote system.

Escape Sequence – +++

If the escape sequence is issued (either from the keyboard or through software), the modem responds by going into the command state. If on-line when this sequence is issued, the modem will go into command state without disconnecting.

The escape sequence consists of three ASCII characters, entered without the **AT** prefix or <**CR**>. ASCII 43 (**+**) is the factory-set character used for the sequence. For more information on this sequence, see **Register S2** in Appendix B, **V-series Smartmodem 2400 S-Registers**.

Guard Time – S12=n

A guard time interval of 1 second prevents the modem from interpreting similar data characters as the escape sequence. To assure that the modem distinguishes the escape sequence from data, pause at least 1 second before and after entering the sequence. The guard time may be changed by writing another value to Register S12. For more information on reading and writing to these registers, see Chapter 4, **Configuration**.

On-line Command – O

If in the asynchronous command state (either by issuing the escape sequence or because a DTR on-to-off transition occurs with **&D1** enabled), the **O** command causes the modem to re-enter the on-line state.

O0	Returns modem to on-line state
O1	Returns modem to on-line state and initiates an equalizer retrain sequence (at 2400 bps)

Connecting with a Remote System

2

This chapter outlines the procedures for placing and receiving calls across telephone lines. Command syntax and dial modifiers used in specifying the remote system and the dialing methods are explained.

Should you experience difficulties connecting with a remote system, you may need to adjust the modem's settings. Chapter 4, **Configuration**, and Chapter 5, **Interface Parameters**, explain how to make the necessary changes to the settings that determine modem operation. Chapter 3, **Troubleshooting**, provides tests to help you determine the source of a communication problem.

Placing a Call

Connection with remote locations are made with the **D** (dial) command. A variety of modifiers can be used with this command to specify the method and number to dial.

Dial Command – D

The basic command for connecting with another modem is **D** followed by the telephone number for the remote system. This command places the modem in originate mode; it then functions as an auto-dialer. For example,

ATD5552368<CR>

dials 5552368. Whether the command is issued on a line by itself, or followed immediately by the telephone number, it must be preceded by the **AT** prefix and terminated with a **<CR>**. No commands (other than dial modifiers) can follow the **D** command on the command line.

The **D** command must be issued from the asynchronous command state. For information on dialing to initiate synchronous communications using a stored number, see Chapter 6, **Data Transmission Options**.

Note: Parentheses, spaces, and hyphens in a dial string are ignored by the auto-dialer, but are counted as characters in the 255 character command buffer.

Dial Modifiers

Dial modifiers are special parameters used to tell the modem what, when, and how to dial the telephone number on the line with the **D** command.

Dial Modifier	Description
0-9 # * A B C D	Digits/characters for dialing
T	Tone dial
P	Pulse dial
W	Wait for dial tone
,	Delay processing of next character
@	Wait for quiet answer
!	Hookflash
;	Return to command state after dialing
R	Reverse mode (to call an originate-only modem)
S=n	Dial a telephone number stored with the **&Zn=x** command

Several dial modifiers can be combined with the **D** command on a single line to perform a series of operations. For example,

ATDT9,5552368 !, #71234; <CR>

instructs the modem to use tone dialing to access a number outside a PBX, pause before dialing, dial the number 5552368, enter a hookflash, pause, and issue the PBX transfer code #7 before dialing extension number 1234, then return to command state before initiating the handshake.

Digits/Characters for Dialing – 0-9 , #, *, A, B, C, D

The digits/characters **0-9 # * A B C D** are used to specify the number to dial. The characters **A B C D # *** represent specific tone pairs and therefore can be used only when tone dialing is selected. These symbols are ignored if included in a telephone number dialed with the pulse method.

Pulse and Tone Dialing – P , T

The modem can dial with pulse or tone. The factory-set method is pulse. Once either method is selected, it is used until the other is chosen, or the modem is reset.

The **T** and **P** modifiers can be issued in conjunction with the dial command, or alone, to designate the method used for subsequent dialings.

Wait for Dial Tone – W

The **W** dial modifier instructs the modem to wait for a dial tone before proceeding. If a dial tone is not detected within 30 seconds, the modem hangs up and returns the **NO DIALTONE** result code. The wait time can be adjusted by changing the value of Register S7. (See Chapter 4, **Configuration**, for information on V-series Smartmodem 2400 S-Registers.)

Delay Processing of Next Character – ,

The comma (,) modifier in a dial string causes the modem to pause for 2 seconds (or the value held in Register S8) before processing the next character or symbol in the command line. The comma is frequently inserted after the 9 (digit generally used to gain outside access from a PBX) to allow sufficient time for the dial tone to occur before the modem dials the telephone number. Multiple commas can be used to produce longer pauses.

Wait for Quiet Answer – @

The @ dial modifier instructs the modem to listen for five seconds of silence before continuing. If a five-second silence has not been detected within 30 seconds, the modem hangs up and returns the **NO ANSWER** result code. If it detects a busy signal, the modem hangs up and returns the **BUSY** result code. If it detects the five seconds of silence, the modem processes the remaining characters in the dial string. This modifier is useful when dialing telephone systems that produce no dial tone.

In the following example, the modem dials 5552368 and waits for a quiet answer. It then dials a security code 85939, waits for a second dial tone, then dials extension 423.

ATDT 5552368 @ 85939 W 423 <CR>

The modem listens for silence only after detecting some sound, such as a ringback signal.

Hookflash – !

The **!** dial modifier issues a flash (hookflash) signal, which causes the modem to hang up for ½ second, then reconnect. This feature can be used to access such PBX features as call transfer.

Return to Command State after Dialing – ;

The semicolon (;) modifier, used only at the end of a command line (just prior to the **<CR>**), instructs the modem to return to the command state immediately after dialing, without breaking the connection.

The **;** is useful when calling an electronic service, such as that offered by a bank, that permits you to use tones to transmit numbers once a connection has been established. The modem can send tones even if your telephone cannot. The example below illustrates the use of the semicolon modifier in communications with an electronic banking service.

Command: **ATDP 555-2368; <CR>**	Dials bank using pulse method.
Result code: **OK**	Command executed, but keeps the modem in command state (no handshake).
Command: **ATDT 4768; <CR>**	Sends an ID code via tones and maintains modem in command state.
Result code: **OK**	Modem in command state; command executed.

In this example, the **;** differs from the **+++** in that the escape sequence places the modem in the command state only when two modems have completed a handshake. The semicolon keeps the modem in command state; no **CONNECT XXXX** result code is displayed.

Originating a Call in Answer Mode – R

The dial modifier **R** (Reverse mode) enables the modem to dial an originate-only modem by placing a call in answer mode. This modifier must be entered at the end of the dialing (**D**) command string, just before the **<CR>**

Storing a Telephone Number – &Zn=x

The **&Zn=x** command is used to store up to four dialing strings in the modem's nonvolatile memory for later dialing. The format for the command is **&Zn="stored number"** where "**n**" is the location 0-3 to which the number should be written. For example, the line **AT&Z2=5552368<CR>** writes 5552368 as the third of the four numbers to the modem's telephone list in nonvolatile memory. The **&Zn=x** command can be used to store a number with as many as 36 characters.

Any dialing string can be saved except the **S** dialing modifier (this would cause a stored dialing string to attempt to dial another stored string), or the **;** modifier if used to connect in synchronous mode 2.

Dialing a Stored Telephone Number – DS=n

A stored number can be dialed by following the dial (**D**) command with the **S** modifier, an equal sign, and the location of the stored number (see **&Zn=x** command above). The format of the modifier is **S=n**, where "**n**" is location 0-3. If **ATDS=2<CR>** were issued, for example, the modem would dial the stored string in memory location three of its telephone list.

Answering a Call

The modem responds to incoming calls with the **RING** result code (if enabled). You can either answer the call manually, or instruct the modem to answer the call automatically.

Answering Manually – A

To answer a call manually, when the modem returns the **RING** result code, issue **ATA<CR>**. The modem will then send a carrier signal to the originating modem and await a carrier signal.

When the modem receives the carrier from the originating modem, it goes on-line and returns the **CONNECT XXXX** result code. If no carrier signal is received within 30 seconds (or the value held in Register S7), the modem hangs up, returns the **NO CARRIER** result code, and enters the command state.

Answering Automatically – S0=

The modem can be set to auto-answer. The modem will attempt to answer incoming calls after the number of rings specified, without waiting for the **A** command.

Enabling Auto-Answer

Auto-answering is controlled with the Register S0. This value determines the number of rings the modem will count before going off-hook and automatically answering the call. Any value greater than 0 and less than 255 enables auto-answer. For example, if **ATS0=3<CR>** were issued, the modem would respond to incoming calls after three rings.

Disabling Auto-Answer

Auto-answer is disabled when the value of Register S0 equals its factory setting of zero (S0=0). The modem displays the **RING** result code each time the phone rings, but does not answer the call unless the **A** command is issued.

Setting Unattended Auto-Answer

The modem can be configured to answer when the system is unattended. With auto-answer enabled, the modem will answer a call after a predetermined number of rings (see **Enabling Auto-Answer** above) and hang up when an on-to-off transition of DTR is detected. (The DTR is the pin on the modem's RS-232C interface that prepares and maintains the connection to a remote system.)

STEP 1: Make sure necessary parameters (such as parity) of the local system match those of the remote system that will be calling.

STEP 2: Set Register S0 to the number of rings desired before the modem should attempt to answer an incoming call.

When the modem is connected to a printer or plotter, or when it is used in synchronous modes 2 or 3, the modem must be configured not to mistake incoming data for command information. Issue the **E0** command to disable command state character echo, and the **Q1** command to disable result code display; this prevents the modem from injecting command or status information into the data stream.

Note: If this configuration is saved with the **&W** command and the modem reset to await calls using this profile, the modem will attempt to connect at the speed at which the **&W** command was issued. For more information on the connection speed associated with a profile, see **Writing a Profile to Memory**, in Chapter 4, **Configuration.**

Switching Between Voice and Data Communication

When the modem and the telephone are connected to the same line, after making a connection, you can switch between voice and data communication without breaking the connection.

Data-to-Voice

Once data communication is established, you can switch to voice communication by picking up the phone connected to the modem, issuing the escape sequence (**+++**), then entering **ATH<CR>**. This causes the modem to release the line to you. When the party at the other end does the same, voice communication can begin.

Voice-to-Data

Issue **ATD<CR>** to put the modem in the originate mode. Note that no phone number is included with this dial command. The other party then issues **ATA<CR>**. When a carrier signal is produced, both parties hang up their phones; data communication can begin once the **CONNECT XXXX** message is received.

Disconnecting/Hanging Up – H

Connections with remote systems can be terminated in several ways. The modem automatically breaks the connection if it is programmed (with the **&D** command) to respond to changes on DTR and it detects an on-to-off transition of this signal. Either user can also break the connection by issuing the escape sequence and the **Z** command. These methods will reset the modem, possibly changing the configuration (see Chapter 4, **Configuration**).

The preferred method for breaking a connection while in asynchronous mode is the **H** command. The **H** command controls the telephone switch hook, which enables the modem to go on- or off-hook when originating or answering a call:

H0 Most frequently used method to cause the modem to hang up, disconnecting it from the remote system.

In modes other than error-control, when the user terminates a call by hanging up the phone with **H0** (or if the modem is configured to respond to DTR and an on-to-off transition occurs), the modem immediately breaks the connection. Because error-control connections may involve data buffering, if the connection is broken immediately, some data may be lost. To prevent this, the modem can be configured to wait up to the specified length of time between receipt of **H0** and actual hangup. This allows the modem to deliver all the data in its buffers. The factory setting for this value, specified in Register S38, is 20. The modem will continue to deliver data until all data is cleared from the buffers, or until the delay expires, whichever condition occurs first. This value is ignored when the modem is operating in any mode other than error-control. For more information, see **Register S38 – Delay Before Forced Hang up**, Appendix B, **V-series Smartmodem 2400 S-Registers**.

A second option for the **H** command is useful when the modem is connected to a key telephone system.

H1 Modem goes off-hook and allows you to monitor the activity on the line if the modem's speaker is enabled. The modem will return the **OK** result code and await further instruction. The light for the extension line to which the modem is connected remains lit until the modem disconnects.

Troubleshooting 3

The test features outlined in this chapter help you determine whether the source of a communication problem is the local modem, the remote modem, or connections in between. Although these tests are oriented toward problems in a new installation, they are also useful if a previously working modem suddenly fails.

Before Calling the Telephone Company

A communication link problem may simply be due to a bad switchboard connection. Before calling the telephone company, however, you should make sure the problem is not being caused by faulty or improperly connected equipment at either end.

Troubleshooting Tips

Some cases of apparent modem failure may be caused by a power surge; changed parameters in your software that prevent it from finding the modem; an incompatible component in the communication link; an improper connection; or simply a device that is not plugged in or turned on. Before you initiate the tests described in this chapter, re-examine your telecommunications equipment to make sure none of the above conditions could be causing the difficulty.

Follow these steps first to eliminate common faults. (If using communication software, consult your software manual for troubleshooting information.)

STEP 1: If your commands don't seem to be reaching the modem, make sure it has been installed properly. Also check to make sure the telephone cable is plugged into the jack marked **To Line** and not into the jack marked **To Phone**.

STEP 2: Issue **AT&F<CR>** to restore the modem's factory configuration, to make sure the modem's settings are not preventing it from making a connection.

STEP 3: If you receive an **OK** result code, issue **ATDT5552368<CR>** (a null number that produces a ringing signal only). If you are calling out of a PBX, remember to include the 9 or other outside access code in the phone number. Listen for a dial tone, followed by the tone dialing beeps. When these occur, they ensure you've entered the phone number correctly, and the local phone line is responding properly.

If there is no dial tone, check the phone line by dialing with an ordinary phone. Note that some PBX systems must be modified to produce at least 48 volts DC for the modem to work.

STEP 4: If you hear the phone on the other end ringing, then the remote phone line is responding properly. Hang up (**ATH0<CR>**).

STEP 5: Try dialing another modem to see if you make a connection. A connection is indicated by two whistling sounds of different tones (the carriers), followed by a hissing sound. The modem should respond with a **CONNECT** result code.

When you have reached this point successfully, both modems have done their job.

If no errors occurred with these steps, the problem is related to software, user error, or modem setup required for your particular installation or for compatibility with the remote system. A frequent problem is an incorrect local flow-control setting. The factory setting, RTS/CTS is appropriate only if the local DTE supports the RTS and CTS circuits and you have installed the modem with a cable that supports these circuits.

Available Tests

Failures in a point-to-point communication link, usually characterized by unacceptably high error rates or total inability to communicate, may be the fault of either the local or remote data terminal equipment, the local or remote modem, or the telephone company circuit. All loopback tests must be performed at 1200 bps or 2400 bps. The modem's diagnostic and test facilities enable you to determine the source of the problem:

- **Local Analog Loopback**: Tests the path that includes the local modem and local data terminal equipment.
- **Local Analog Loopback with Self Test**: Checks the operation of the local modem with an internally generated test pattern.
- **Remote Digital Loopback**: Verifies the path that includes the local data terminal equipment, local modem, remote modem, and telephone circuit. This test requires a CCITT compatible modem.*
- **Remote Digital Loopback with Self Test**: Tests the path that includes the local modem, remote modem, and telephone circuit with an internally generated test pattern. This test requires a CCITT compatible modem.*
- **Local Digital Loopback**: Tests the communication link, the local modem, and the remote modem (permits a non-CCITT compatible, remote modem to engage in a digital loopback test with the local modem).*
- **Internal Memory and Product Code**: Checks the modem's ROM and displays the product/firmware revision numbers.

*These tests must be performed while the modem is configured for asynchronous operation. Before beginning, issue **AT&Q0<CR>**. For more information on configuring the modem, see Chapter 4, **Configuration**.

Do not call the phone company until you have performed these tests and ruled out operator errors and failures of your equipment or of the remote equipment. In addition, the test results may be of help when explaining the problem.

Performing a Test

Tests are performed by issuing AT commands to the modem. Some tests require a connection be established. Others, like the internal memory diagnostics and analog loopback tests, check the local modem only and therefore do not require a link with a remote modem. The procedures below explain how to initiate and terminate tests.

Initiating a Test

All of the diagnostic tests are initiated from the asynchronous command state. To use the loopback tests:

- establish a connection (when directed) and return to the command state by issuing the escape sequence (+++), or if the **&D1** DTR option is selected, by generating an on-to-off transition on DTR
- issue the appropriate **&T** command once in the command state

The results of these tests may be of some use if you must contact Hayes Customer Service.

Terminating a Test in Progress — &T0

A test may be terminated from the command state at any time by issuing the **&T0** command to the modem. If the local analog loopback or remote digital loopback tests are being performed, it is necessary to issue the escape sequence to return to the command state prior to issuing **&T0**. Commands that follow **&T0** in a command line are ignored.

Entering the **H0** command will terminate a test, leaving the value of Register S18 at its current value; resetting with the **Z** command terminates the test, resetting the value in Register S18 to 0. A soft reset with the **Z** command reconfigures the modem with the selected user profile. Both of these techniques break the connection.

Setting the Test Timer – S18=

The test timer determines the duration of a test. Register S18, when set to a non-zero value, establishes the duration of the modem's diagnostic tests. When a test has been active for a period equal to the value chosen for this register (from 1 to 255 seconds), the modem will automatically halt the test and return to the command state. For example, if the register value is set to 10 with **ATS18=10<CR>**, when a test is initiated, it will continue for 10 seconds. (See Chapter 4, **Configuration**, for details on writing to S-Registers.) Loading S18 with zero disables the test timer (factory setting). Tests must then be terminated with the **&T0** command or by resetting the modem.

Testing with Analog Loopback

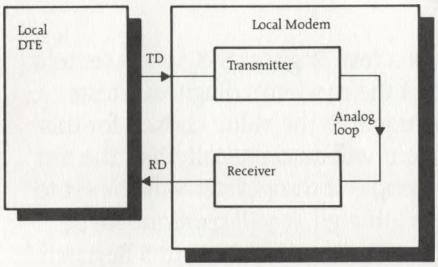
Use the analog loopback tests if you suspect the modem is causing errors in data transmission.

The local analog loopback test will verify both the local modem and the local data terminal equipment. If this test fails, the data terminal equipment rather than the modem may be at fault. The local analog loopback with self test will verify the integrity of the local modem only. If this test fails, the local modem is at fault. If the modem passes both of these tests, attempt the remote digital loopback with self test to verify the modem-to-modem communication path.

Local Analog Loopback – &T1

This test is used to verify the integrity of the path between the local modem and the local data terminal equipment (see also **Local Analog Loopback with Self Test**).

Local Analog Loopback (&T1)



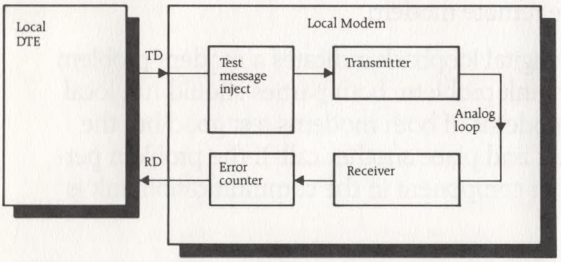
Set the local data terminal equipment to echo characters and the local modem to echo commands received from the local data terminal (the **E1** option selected). Initiate the test with **&T1**. Type a few sentences; they will be looped back to the local data terminal.

If the modem echoes your keyboard input to the screen as you typed it, the modem is operating correctly. If not, the modem may be faulty. To end the test, enter the command state and issue the **&T0** command.

Local Analog Loopback with Self Test – &T8

This test is used to verify the integrity of the local modem's transmit and receive circuits. During the test, a self-test pattern is transmitted from the modem, looped back into the receive circuit, and compared with the original pattern for any errors.

Local Analog Loopback with Self-Test (&T8)



Set the local data terminal equipment to echo characters and the local modem to echo commands received from the local data terminal (the **E1** option selected). Initiate the test with **&T8**. When the test is terminated with the **&T0** command, the modem will return a three-digit number indicating test results (e.g., 000=no errors; 012=12 errors). If the error count reported is 000, the local modem passed the test. An error count of 255 indicates that 255 or more errors were detected.

Testing with Digital Loopback

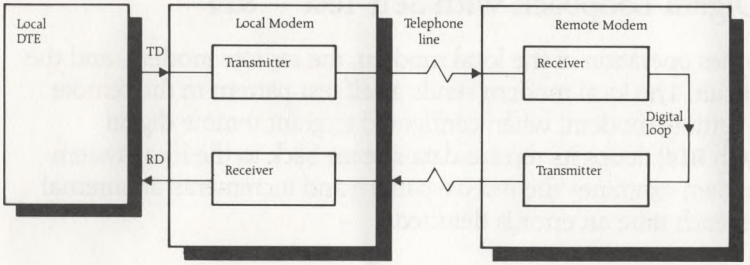
Local digital loopback and remote digital loopback together test all of the components in the communication link, including the modems. Data sent from one modem is looped back to it by the other modem without going through the other modem's data terminal equipment. Remote digital loopback tests the communication link from the local modem. Remote digital loopback with self test verifies the communication link from the local modem to the remote modem and back. Local digital loopback tests the communication link from the remote modem.

When either local or remote digital loopback indicates a modem problem rather than a communication link problem, both parties should run local analog loopback to test the modems. If both modems test good but the problem still exists, disconnect and place another call. If the problem persists, the phone line or another component in the communication link is faulty.

Remote Digital Loopback – &T6

Remote Digital Loopback verifies the operation of both modems, the local data terminal equipment, and the telephone circuit by commanding the remote modem to loop data sent to the remote system back to the local modem.

Remote Digital Loopback (&T6)



Before initiating remote digital loopback, establish a connection with a remote modem. Then, enter the command state and issue the **&T6** command to begin the test.

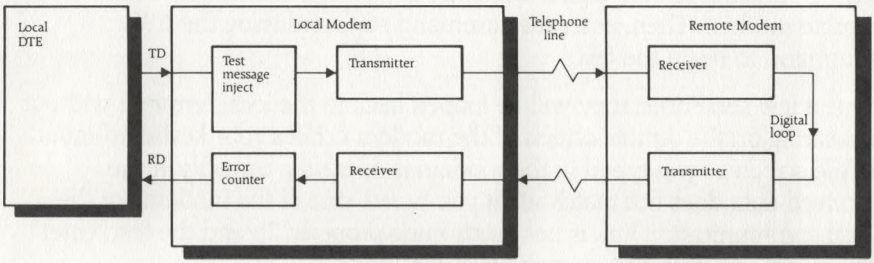
Type a few sentences; they will be looped back to the local terminal without appearing on the remote screen. If the modem echoes your keyboard input to the screen as you typed it, the modem is operating correctly. If the received data does not match what you typed, one of the modems or the local communication link is not functioning properly. To end the test, enter the command state and issue the **&T0** command.

Note: The local modem requests a digital loopback with the remote modem through a CCITT V.54 standard handshake sequence. The remote modem automatically acknowledges the request if it has been conditioned to do so with the **&T4** command. (See the discussions on the **&T4** and **&T5** commands.) If the remote modem is not Hayes-compatible, it may not permit this test to be executed from the local modem (response will be "**ERROR**"). However, if the remote user can put the modem into local digital loopback or an equivalent state, the test can be performed from the local modem.

Remote Digital Loopback with Self Test – &T7

This test verifies operation of the local modem, the remote modem, and the telephone circuit. The local modem sends a self test pattern to the remote station. The remote modem, when configured to grant remote digital loopback (with **&T4**), loops its receive data stream back to the local system. The local modem examines the receive pattern and increments an internal error counter each time an error is detected.

Remote Digital Loopback with Self-Test (&T7)



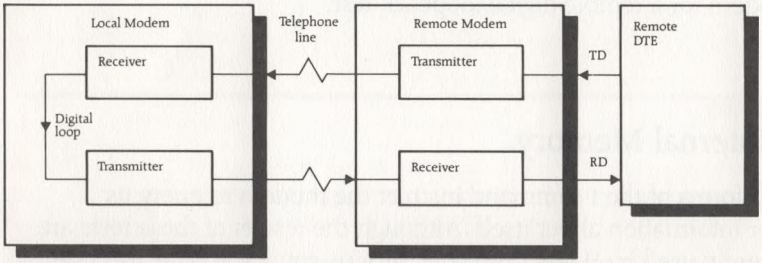
Before beginning the test, establish a connection with a remote modem. Then, enter the command state and initiate the remote digital loopback by issuing **&T7**. When the test is terminated with the **&T0** command, the modem will return a three-digit number indicating test results (e.g., 000=no errors; 012=12 errors). If the error count reported is 000, the local and remote modems and the telephone circuit passed the test. If errors were encountered, initiating a local analog loopback test will further isolate the source of the problem. An error count of 255 indicates that 255 or more errors were detected.

Local Digital Loopback – &T3

Local digital loopback tests the communication link and the remote modem. During this test, the local modem loops incoming data directly back to the remote modem.

To initiate local digital loopback, establish a connection with a remote modem, then enter the command state and issue the **&T3** command.

Local Digital Loopback (&T3)



The operator at the remote system should type in a few sentences. They will be looped back to the remote data terminal. When the operator at the remote system indicates that the test is complete, issue the **&T0** command to end the test. If the operator at the remote system reports that the data came back without errors, the remote modem and the communication link are functioning properly.

Grant RDL Request from Remote Modem – &T4

This command configures the local modem to grant a request from the remote modem for a remote digital loopback test (factory setting).

Deny RDL Request from Remote Modem – &T5

This command prohibits the local modem from granting a request from the remote modem for a remote digital loopback test.

Testing Internal Memory

The various forms of the I command instruct the modem to query its memory for information about itself. Although the results of these tests are most frequently used by Hayes Customer Service, some software also uses the responses when determining how to set up the modem prior to communication. These tests request information about the modem's firmware; therefore, it is unnecessary to connect with a remote system before issuing the I command.

Displaying Product Code – I0

If the **I0** command is issued, the modem will respond with its product code in the form of a three-digit ASCII string (e.g., 24x–where "x" is the modem revision level) followed by a carriage return and line feed. Generally, this test is performed to determine the revision level of a product.

Testing ROM Checksum – I1

The **I1** command computes the modem's ROM checksum. The result of this command should be a three-digit number, the sum of all bytes in ROM. Hayes Customer Service can compare this number to the correct sum for the product to determine if a bit in the ROM has somehow been destroyed.

Testing ROM Memory – I2

The **I2** command computes the ROM checksum and compares the total against a stored value held in ROM. Rather than returning a value in the way the **I1** command does, the **I2** command generates a result code. If the two figures agree, internal memory is complete and **OK** is displayed. If the totals are different, the **ERROR** code is returned.

Hayes Product Support

If after performing these tests you cannot isolate the problem, contact the Hayes Advanced Systems Dealer from whom you purchased the V-series Smartmodem 2400. Your dealer has extensive training in V-series applications and experience with Hayes Smartmodem products. The results of the tests described above and in your modem documentation will provide information necessary for the person who will assist you, and will help you explain any difficulties you may encounter.

Configuration

4

Setup of older modems requires adjustments to DIP switches; however, the V-series Smartmodem 2400 is configurable entirely from the keyboard of an asynchronous data terminal. Combinations of command settings and S-Register values can be stored as user profiles to supplement the factory configuration that is recalled on power-up and reset. This chapter outlines the techniques for displaying, modifying, and selecting modem configuration. Procedures for reading and writing to V-series Smartmodem 2400 S-Registers are also included.

For those applications requiring that the modem's "smart" functions be disabled after configuration, instructions are also included for putting the modem into "dumb mode."

Configuration Parameters

Modem configuration is maintained as a collection of parameters and parameter values, assigned to AT commands and S-Registers. These parameter settings are accessed from three areas: factory configuration, active configuration, and user profiles. The factory configuration reflects the settings appropriate for most communication needs; however, the modem can be reconfigured for specific operating conditions. For example, tone rather than pulse dialing can be specified as part of the configuration to be recalled on power-up.

The majority of the parameters can be saved in nonvolatile memory; some (like backspace and carriage return characters) are non-storable and must be reconfigured individually as necessary following each modem reset.

Modifiable Parameters

The tables below describe the parameters and their settings in the factory configuration. Also provided are the AT Commands or S-Registers that control the values. Note that although all of these values can be changed and used as an active configuration, not all of them can be stored as part of a user profile.

Non-Storable Parameters

Changes to these parameters are held in RAM; when the modem is powered down and back up, the values are reset to the factory settings, even if the currently defined values in the active configuration are saved.

Parameter	Value in Factory Configuration	S-Register Factory Setting
Backspace character	ASCII 08	S5=8
Carriage return character	ASCII 13	S3=13
Escape sequence character	ASCII 43	S2=43
Line feed character	ASCII 10	S4=10
Ring count	0	S1=0

If these values must be set prior to using the modem, you must make the necessary changes by writing to the appropriate S-Register each time the modem is powered up or reset.

Storable Parameters

The modem's active configuration can be modified and the storable parameters saved in nonvolatile memory as a user profile.

Parameter	Value in Factory Configuration	Command/S-Register Factory Setting
Auto-answer	disabled	S0=0
Carrier detect response time	0.6 sec.	S9=6
Carrier control	carrier switching enabled	C1
Command state echo	enabled	E1
Communication mode	error-control	&Q5
Default user profile	profile 0	&Y0
Delay before forced hang up	up to 20 seconds	S38=20
Desired DCE line speed	speed of last AT command	S37=0
DCD circuit option	always on	&C0
Dial method	pulse dial	P
DSR circuit option	always on	&S0
DTMF tone duration	95 millisec.	S11=95
DTR circuit option	modem ignores DTR	&D0
DTR pulse width	.05 sec.	S25=5
Duration of delay for comma	2 sec.	S8=2
Escape sequence guard time	1 sec.	S12=50
Flow-control method	RTS/CTS	&K3
Guard tone selection	disabled	&G0
Line type	dial-up	&L0
Long space disconnect	disabled	Y0
Lost carrier until hang up time	1.4 sec.	S10=14
Modulation handshake	enabled	N1
Negotiation failure treatment	connect in async mode	S36=1
Negotiation progress messages	disabled	W0
On-line echo	disabled	F1
Pulse dial make/break ratio	39%/61%	&P0
RDL request	granted	&T4
Result codes	enabled	Q0
Result codes display	as words	V1
Result codes subset	extended (0-7, 10-12)	X4
Rings to answer on	0	S0=0
RTS/CTS circuit (non error-control)	CTS tracks RTS	&R0
RTS/CTS delay	.01 sec.	S26=1
Speaker control	enabled	M1
Speaker volume	medium	L2
Standard at 1200 bps	Bell 212A	B1
Telco jack type	RJ-11, RJ-41S, RJ-45S	&J0
Test timer duration	0	S18=0
Transmit clock source	modem	&X0
Wait for carrier signal duration	30 sec.	S7=30
Wait for dial tone duration	2 sec.	S6=2

Factory Configuration

The command settings and S-Register values installed at the factory are stored in the modem's firmware memory (ROM). To suit your use of the modem, any of these values can be adjusted, but the factory-set configuration remains fixed in ROM. When power is first applied to the modem, it will be configured using this collection of factory-set parameters and parameter values (see **Storable Parameters** and **Non-Storable Parameters**).

Active Configuration

The settings defined after power-up comprise the active configuration. The current S-Register values and command settings defining this configuration control the modem's operation and are used until the modem is turned off or reset.

User Profiles

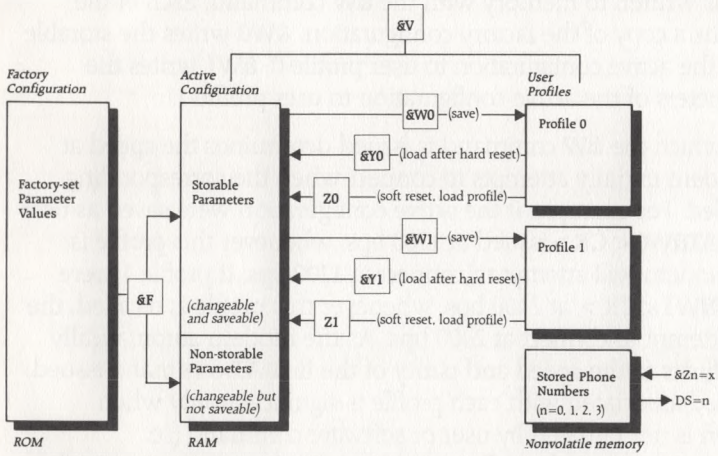
The majority of the settings that configure the modem can be saved in memory. As many of the parameters as necessary can be changed to suit your use of the modem; those not altered retain their factory settings. If saved, the parameters of the active configuration, whether changed or left with the factory setting, are saved as a user profile. The modem can store two user profiles (see **Storable Parameters**).

When a selected profile is recalled, its settings replace the corresponding settings in the active configuration. These profiles provide a way to begin using the modem immediately on reset or power-up. Recalling a user profile does not completely reconfigure the modem (see **Non-Storable Parameters**). The parameters and parameter values not stored in the user profile are automatically reset to their factory settings.

Managing Modem Configuration

By setting up user profiles, the modem can be configured for multiple applications. The appropriate profile can be recalled when needed, or the factory configuration used, if desired. The modem can easily be reconfigured, and settings examined. These operations and others relating to modem setup and use can be performed with the AT commands described in this section.

The diagram below illustrates the interaction between factory configuration, active configuration, and user profiles, and how parameters are stored and recalled.



Command	Function
&F	Load Factory Configuration into Active Configuration
&V	Display active configuration and user profiles and stored phone numbers.
&Wn	Save and store configuration as User Profile 0 or User Profile 1.
&Yn	Restore User Profile 0 or User Profile 1 as active configuration after a hard reset.
Zn	Software reset; restore User Profile 0 or User Profile 1 as active configuration.
&Zn=x	Store phone number (x) in location "n" (0, 1, 2, 3).
DS=n	Dial number stored in location "n".

Telephone numbers are not part of a user profile. However, in synchronous mode 2 – Stored Number Dial (see Chapter 6, **Data Transmission Options**), telephone number 0 is automatically dialed, regardless of the profile designated for use on power-up or to be recalled on reset. For information on storing dialing strings, see the **&Zn=x** command in Chapter 2, **Connecting with a Remote System**.

Writing a Profile to Memory – &W

The storable parameters of the active configuration (the settings currently in use) can be saved in memory as one of two user-defined profiles. Until a configuration is written to memory with the **&W** command, each of the profiles contains a copy of the factory configuration. **&W0** writes the storable parameters of the active configuration to user profile 0; **&W1** writes the storable parameters of the active configuration to user profile 1.

The speed at which the **&W** command is issued determines the speed at which the modem initially attempts to connect when the corresponding profile is recalled. For example, if the active configuration were saved as user profile 0 with **AT&W0<CR>** issued at 1200 bps, whenever this profile is recalled, the modem will attempt to connect at 1200 bps. If profile 1 were saved with **AT&W1<CR>** at 2400 bps, whenever this profile is recalled, the modem will attempt to connect at 2400 bps. As the modem automatically detects and adjusts to the speed and parity of the first AT command issued, the stored speed associated with each profile is significant only when communication is not initiated by user or software command (i.e., unattended auto-answer and synchronous mode 2–Stored Number Dial).

Retrieving the Factory Configuration – &F

The **&F** command recalls the configuration stored in ROM. This operation completely replaces the values in the active configuration with those comprising the factory configuration.

Designating a Default User Profile – &Y

Either of the two user profiles can be designated as the default to recall when the modem is powered up. Stored user profile 0 is selected with **&Y0**; **&Y1** selects stored user profile 1. The modem is configured from the factory to recall user profile 0 on power-up.

Recalling a Stored User Profile – Z

The **Z** command resets the modem and recalls a stored user profile. Either profile can be recalled with the **Z** command. **Z0** resets the modem, recalling stored user profile 0; **Z1** resets the modem and recalls stored user profile 1 (see the **&W** command). The storable parameter values in the user profile are used in place of the parameter values defined by the factory configuration. The non-storable parameters will hold the values defined by the factory configuration until they are changed by writing to the appropriate S-Register.

Viewing Active Configuration and User Profiles – &V

The **&V** command displays the active configuration and user profiles 0 and 1; also displayed are any stored telephone numbers. The **&V** command should be issued on a line by itself, not in conjunction with other commands.

Resetting the Modem

The modem can be reset by software and by hardware. Both methods initialize the modem and recall the two user-defined profiles.

Soft Reset

The modem can be reset by issuing the **Z** command from the keyboard or through software. Any non-storable parameters previously set by commands are returned to their factory settings. Issue the **Z** command on a line by itself. (Subsequent commands on the same line are ignored.) **Z0** recalls user profile 0, stored with **&W0**; **Z1** recalls user profile 1, stored with **&W1**. The modem will respond with the **OK** result code when the reset is complete.

Hard Reset

Powering the modem off and on performs a hard reset. Any non-storable parameters are returned to their factory settings, and the user profile defined as the default for power-up will be recalled (see the descriptions of the **&W** and **&Y** commands). If the modem is configured to reset if an on-to-off transition of DTR occurs, the reset will initialize the modem and recall the default user profile even though the transition was not caused by a power off/on. Commands issued during a hard reset are not recognized.

S-Register Configuration

S-Registers provide special access to modem configuration. For the experienced user, these registers offer advanced techniques for controlling the operations of the modem. The value of each S-Register is expressed as an ASCII character string, a timing parameter, an option, or a counter.

Reading an S-Register Value — Sr?

The command to read an S-Register value is **Sr?** (where "**r**" is the number of the register). For example, **ATS0?<CR>** reads the value of S-Register 0. If this command were issued to a modem with the factory settings as the active configuration, the modem would return the value 000.

Several S-Registers can be read at once by including them on the same command line. For example, **ATS2?S4?S7?<CR>** reads the values of three registers and returns the values 043, 010, 030.

Note: The **&V** command can also be used to read the current values of selected S-Registers.

Changing an S-Register Value — Sr=n

The command to change an S-Register value is **Sr=n** (where "**r**" is the number of the register and "**n**" is the assigned value). For example, **ATS0=1<CR>** changes the value of S-Register 0 from its factory default of 0 to 1, which enables auto-answer. This new value is stored and used until the modem is turned off or reset. Values written to registers S0, S6-S12, S18, S25, S26, and S36-S38 are written to nonvolatile memory if the active configuration is saved with the **&W** command. The saved value for the register(s) will be recalled when the modem is reset.

Addressing an S-Register — Sr

You can set a pointer to a particular S-Register with **Sr** (where "**r**" is the number of the register). For example, **ATS7<CR>** sets a pointer to Register S7. Until another register is specified, the value of Register S7 can be read with **AT?<CR>** and changed with **AT=n<CR>**.

S-Register Chart

The following chart summarizes the modem's S-Registers.

Register	Range	Description	Factory Setting
S0	0-255 rings	Select ring to answer on.	0
S1	0-255 rings	Ring count (incremented with each ring).	0
S2	0-127 ASCII	Define escape sequence character.	43 (+)
S3	0-127 ASCII	Define carriage return character.	13
S4	0-127 ASCII	Define line feed character.	10
S5	0-32, 127 ASCII	Define back space character.	8
S6	2-255 sec.	Select wait time before blind dialing.	2
S7	1-255 sec.	Select wait time for carrier/dial tone.	30
S8	0-255 sec.	Select duration of comma dial modifier.	2
S9	1-255 1/10 sec.	Select carrier detect response time.	6
S10	1-255 1/10 sec.	Select delay between carrier loss/hangup.	14
S11	50-255 msec.	Define duration/spacing of tones.	95
S12	0-255 1/50 sec.	Define escape sequence guard time.	50
S13-15		Reserved.	
S16		Reserved (**Note:** functions for this register controlled by the &T commands).	
S17		Reserved.	
S18	0-255 sec.	Select test timer.	0
S19-24		Reserved.	
S25	0-255 1/100 sec.	Select DTR change detect time.	5
S26	0-255 1/100 sec.	Select RTS to CTS delay.	1
S27- S35		Reserved.	
S36	0,1	Select negotiation failure treatment.	1
S37	0-3, 5, 6	Select desired DCE line speed.	0
S38	0-255 sec.	Select delay before forced hang up.	20

For a complete description of the uses and recommended settings for these registers, see Appendix B, **V-series Smartmodem 2400 S-Registers.**

Dumb Mode Configuration

Although the V-series Smartmodem 2400 functions as an intelligent communication component, you may want to disable its command recognition and result code display for certain applications. This configures the modem for "dumb mode."

Dumb mode is useful in special asynchronous applications such as auto-answer. When the modem is connected to a printer, for example, the printer can print data while unattended. Also, if using the modem as a dedicated synchronous device, you may want to disable command recognition to prevent the modem from accidentally interpreting synchronous data communication from the DTE as an AT command.

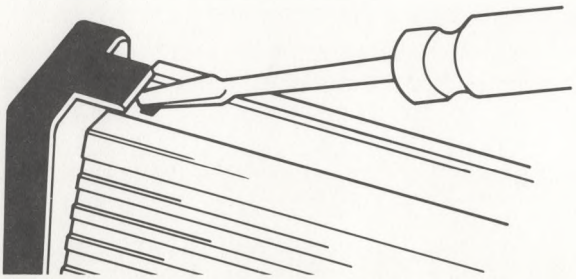
The following steps configure the modem for "dumb mode" operation:

STEP 1: With the modem connected to a computer or terminal from which you can issue AT commands, select the configuration necessary for your application (e.g., auto-answer).

STEP 2: Save this active configuration as part of a user profile with the **&W** command. With the **&Y** command, designate it as the user profile to recall on power-up.

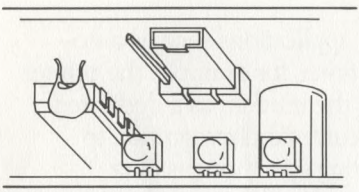
STEP 3: Turn off the modem. Disconnect the modem from the power source, the telephone line, and the computer.

STEP 4: Remove the modem's front panel by inserting a screwdriver into the notch on the side of the front panel, then twist the screwdriver slightly to loosen the panel.

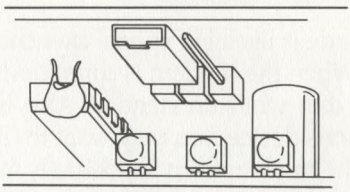


The dumb mode jumper sits at the front edge of the upper board. In its factory position, the jumper joins the two rightmost pins, configuring the modem for intelligent operation.

STEP 5: To disable command recognition and result code generation, place the jumper over the two leftmost pins (dumb mode position).



Command
Recognition Enabled



Command
Recognition Disabled

STEP 6: Replace the front panel, and reconnect the modem to the computer or terminal (or to the device for which you have configured the modem's operation, e.g., printer). Reconnect the modem to the telephone line and to the power source.

STEP 7: Turn on the modem and the device to which it is connected.

The modem is now configured for dumb mode operation with the attached device. The modem's intelligent functions can be restored by placing the jumper back on the two rightmost pins.

Interface Parameters

5

The V-series Smartmodem 2400 can be customized to suit a variety of installation and application requirements. The commands in this chapter are used to specify the modem's interface to the local computer and to the telephone line. Also discussed are the commands to select display, audio, and result code options.

Telephone Line Connection

When connecting the modem to the telephone line, settings for line type, guard tone selection, jack type, make/break ratio, long space disconnect option, and communication standard can be adjusted.

Line Type – &L

The modem can be configured for either two-wire, dial-up or conditioned leased line operation.

&L0 Dial-up line (factory setting)

&L1 Leased line

When connecting the modem to a four-wire private line, a two-wire to four-wire hybrid is necessary to adapt the two-wire modem to a four-wire communication facility. For intrastate designation, contact your local public utilities commission. A hybrid is not required if the modem is connected to a two-wire line.

To make a connection over a leased line, one modem should be configured to originate with the **D** command, and the other to answer with the **A** command. The two modems will automatically connect.

Guard Tone Value – &G

Although not required for modem communications in the United States, guard tones can be selected with the **&G** command.

&G0 No guard tones (factory setting)

&G1 550 Hz guard tone

&G2 1800 Hz guard tone

Jack Type – &J

The **&J** command designates the type of jack with which the modem is connected to the telephone line.

&J0 RJ-11, RJ-41S, or RJ-45S type phone jack (factory setting)

&J1 RJ-12 or RJ-13 type phone jack

The **&J0** setting is appropriate for most installations. If attaching the modem to a multi-line (key telephone) system equipped with RJ-12 or RJ-13 jacks, adjust the setting with **&J1**. This supports multi-line systems with "in-use" lights.

Caution: RJ-11 telephone connections that provide power for telephones with lighted dials can damage the modem if RJ-12/RJ-13 operation is selected. If the modem will be connected to an RJ-11 jack, leave the selection at its factory setting (**&J0**).

Pulse Dial Make/Break Ratio – &P

The **&P** command is used to select the ratio of the off-hook (make) to on-hook (break) interval used when pulse dialing.

&P0 39%/61% make/break ratio (factory setting)

&P1 33%/67% make/break ratio

Long Space Disconnect – Y

The **Y** command enables/disables the modem's response to a long space disconnect signal. When enabled, if the modem receives a continuous break from the remote modem for a period greater than or equal to 1.6 seconds, the modem hangs up. If the **H0** command is initiated or the modem detects an on-to-off transition on DTR (if the **&D2** option is selected), the modem disconnects, and transmits a break signal (for 4 seconds) before going on hook. If disabled, the modem does not respond to a long space disconnect.

Y0 Modem does not recognize or respond to a long space disconnect (factory setting)

Y1 Modem recognizes and responds to a long space disconnect

Communication Standard – B

The modem can initiate a handshake using either Bell or CCITT standards at 1200 bps.

B0 CCITT V.22 standard for communication at 1200 bps

B1 Bell 212A standard for communication at 1200 bps (factory setting)

When communicating at 0-300 bps or 2400 bps, the selection made with the **B** command is ignored. Subsequent 1200 bps transmissions will, however, use the communication standard selected by this command.

Modulation Handshake – N

The **N** command determines whether the modem performs a handshake with a remote system if the speeds of the two modems are different. This command can be used to assure that connection is made at the specified speed only. If the selected speed can be achieved using more than one communication standard (e.g., Bell 212A or CCITT V.22 at 1200 bps), the modem will also reference the selection made with the **B** command.

N0 Require that the speed of the connection be that specified by the value held in S37; if S37=0, the speed of the connection must match that at which the last AT command was issued

N1 Permit handshaking to occur at any DCE speed supported by both modems (factory setting)

In the factory setting, the modem will attempt to make the connection by falling back or rising up to the speed of the remote modem.

Carrier Control – C

The **C** command is used in some Hayes modems to control the transmit carrier. The V-series Smartmodem 2400 is preset to turn carrier on and off as necessary (the **C1** option). The signal is on when the modem is calling, answering, or connected to a remote modem, and is off when it is not. The **C0** option is not valid for the V-series Smartmodem 2400.

C0 Not permitted; returns **ERROR** result code

C1 Normal transmit carrier switching (preset)

Display and Audio Settings

The modem's display and audio parameters can be adjusted to suit user preference or the remote system's requirements.

Character Echo – E, F

Depending upon the capabilities and/or character echo combination supported or selected by the local and remote systems, the characters you type may appear on your screen twice, or might not appear at all.

Command State Character Echo

The **E** command determines whether characters are echoed to the data terminal from the modem in the command state.

E0 Disables command state character echo

E1 Enables command state character echo (factory setting)

Select the command suitable to the capabilities and settings of your system. If what you type in the command state appears double, issue the **E0** command; if you cannot see what you type, issue the **E1** command.

On-Line State Character Echo

In lower speed modems, the **F** command determines whether characters are echoed to the terminal from the modem in the on-line state. In high speed modems, this function is generally controlled by communication software. The V-series Smartmodem 2400 does not support on-line character echo.

F0 Returns **ERROR**; does not alter setting

F1 On-line state character echo disabled (preset)

Speaker Control – M, L

The modem's audio monitor can be adjusted to suit a number of operating conditions.

Speaker On/Off

The **M** command specifies when the speaker functions.

M0	Always off
M1	On until carrier detected (factory setting)
M2	On continuously
M3	On after dialing until carrier detected

Speaker Level

The range of the speaker's volume is controlled with the **L** command.

L0 or L1	Low
L2	Medium (factory setting)
L3	High

Result Codes – Q, V, X, W

The V-series Smartmodem 2400 supports the following result codes. Various combinations of forms, subsets, and display can be selected with the commands discussed in this section.

Result Code Definitions

Numeric	Verbose	Description
0	OK	Command executed
1	CONNECT	Connection at 0 to 300 bps
2	RING	Ring signal detected
3	NO CARRIER	Carrier signal not detected, or lost
4	ERROR	Invalid command, checksum, error in command line, or command line exceeds 255 characters
5	CONNECT 1200	Connection at 1200 bps
6	NO DIALTONE	No dial tone detected
7	BUSY	Busy signal detected
8	NO ANSWER	No silence detected when dialing a system not providing a dial tone
10	CONNECT 2400	Connection at 2400 bps
11	CONNECT 4800	Connection at 4800 bps
12	CONNECT 9600	Connection at 9600 bps
40	CARRIER 300	Carrier detected at 300 bps
46	CARRIER 1200	Carrier detected at 1200 bps
47	CARRIER 2400	Carrier detected at 2400 bps
70	PROTOCOL: NONE	Asynchronous mode
71	PROTOCOL: ERROR-CONTROL/LAP-B	Error-control mode with LAP-B protocol
73	PROTOCOL: ERROR-CONTROL/AFT	Error-control mode with AFT

Note: CONNECT XXXX messages refer to modem-to-DTE connection speeds; **CARRIER** messages refer to DCE line speeds of the connection.

Result Code Display

Display of result codes for commands issued to the modem can be controlled with three separate commands.

The **Q** command enables or disables result codes.

Q0 Modem returns result codes (factory setting)

Q1 Modem does not return result codes

Q2 Modem returns result codes when originating a call; does not return result codes when answering a call

Result Code Form

The **V** command determines the form of result codes, whether they are returned as words (e.g., **OK**, **ERROR**, **CONNECT**) or as numbers.

V0 Result codes displayed in numeric form

V1 Result codes displayed in verbose (English) form (factory setting)

For a comparative listing of numeric and verbose result codes, see the chart above outlining result code definitions.

Result Code Set and Dialing Capabilities

The **X** command selects result codes and enables dialing capabilities such as call progress monitoring.

X0 Basic set of result codes (0-4) enabled

The modem blind dials and sends the **CONNECT** result code once a satisfactory connection is established. Dial tone and busy signal are not recognized.

X1 Result codes 0-5, 10-12 enabled

The modem blind dials and sends the appropriate **CONNECT XXXX** result code once a satisfactory connection is established. Dial tone and busy signal are not recognized.

X2 Result codes 0-6, 10-12 enabled; dial tone detected

The modem waits for a dial tone before dialing, then sends the appropriate **CONNECT XXXX** result code once a satisfactory connection is established. The **NO DIALTONE** result code is sent if a dial tone is not detected within 5 seconds. Busy signals are not recognized.

X3 Result codes 0-5, 7, 10-12 enabled; busy signal detected; dial tone not detected

The modem blind dials and sends the **CONNECT XXXX** result code once a satisfactory connection is established. The **BUSY** result code is sent if a busy signal is detected, but dial tones are not detected.

X4 Result codes 0-7, 10-12 enabled; dial tone and busy signal detected (factory setting)

The modem waits for a dial tone before dialing, then sends the appropriate **CONNECT XXXX** result code once a satisfactory connection is established. The **NO DIALTONE** result code is sent if a dial tone is not detected within 5 seconds. The **BUSY** result code is sent if a busy signal is detected.

Note: The **NO ANSWER** result code (**8**) is displayed only when a predetermined duration of silence expires when dialing a system not providing a dial tone. The display of this result code is independent of the **X** command. This result code is returned only when the @ dial modifier is included in the dial (**D**) command string.

Negotiation Progress Reporting

An additional set of result codes can be enabled with the **W** command to report progress of the negotiation phase of the error-control mode. These codes report the carrier speed (300-2400 bps) and the link level protocol (LAP-B or AFT). If enabled, these messages report the carrier speed, then the protocol. These messages can also be reported in either numeric or verbose form. For example, both **71** and **PROTOCOL: ERROR-CONTROL/LAP-B** indicate that the protocol is extended LAP-B across an error-control link.

W0 Error-control call progress not reported (factory setting)

W1 Error-control call progress reported

If the error-control link is negotiated, and a connection is made, the appropriate **CONNECT XXXX** message is reported.

When in error-control mode, the **CARRIER** message may indicate one speed, while the **CONNECT XXXX** message reports another. The modem to DTE speed can be higher than the DCE line speed because of adaptive compression and the capability of the modem to communicate with the remote modem at one speed and with the attached device at another.

DTE Connection

The modem and the DTE interface across signal lines defined according to RS-232C standards. The modem's responses to these signals (i.e., Transmit Clock Source, DCD, DTR, DSR, RTS, and CTS) can be adjusted with AT commands. Additionally, several methods can be enabled to meet software and hardware requirements for data flow-control between the two devices. As configured from the factory, the modem's RS-232C responses and flow-control settings are appropriate for most asynchronous communications. Unless the modem will be configured for synchronous operation or for error-control mode, adjustment is unnecessary.

Transmit Clock Source – &X

The source of the synchronous transmit clock (Transmit Signal Element Timing) is programmable using the **&X** command. The modem, data terminal, or receive carrier can generate the transmit clock.

&X0 Modem generates transmit clock and applies it to pin 15 (factory setting)

&X1 Data terminal equipment generates the transmit clock on pin 24; modem applies this clock to pin 15

&X2 Modem derives the transmit clock from the receive carrier signal and applies it to pin 15

This command is used to select the clock source for communications in synchronous modes 1, 2, 3, and 4. The factory setting is appropriate for communications in other modes.

Data Carrier Detect (DCD) – & C

In synchronous mode, the modem turns on the DCD circuit when an acceptable data carrier from the remote modem is present. In this mode, DCD (pin 8 on the RS-232C interface) always tracks the data carrier from the remote modem and goes on when the data carrier is detected.

In asynchronous or error-control mode, the modem can be programmed to keep the DCD interchange circuit on at all times, ignoring data carrier presence or absence, or to turn on the DCD when a data carrier is detected.

The **&C** command designates the DCD option used in asynchronous mode:

&C0 DCD always on; state of data carrier from the remote modem ignored (factory setting)

&C1 DCD tracks data carrier from remote modem; DCD is on when data carrier detected

If a synchronous mode is selected, DCD always functions as if **&C1** were enabled.

Data Terminal Ready (DTR) – &D

The DTR circuit (pin 20 on RS-232C interface) prepares and maintains the modem's connection to a communication channel. In synchronous modes 2 and 3, the data terminal controls DTR and the modem ignores any settings made with the **&D** command. In asynchronous mode, several DTR options are available.

&D0 Modem ignores changes in DTR status (factory setting)

&D1 Modem enters command state when an on-to-off transition of DTR is detected

&D2 Modem hangs up, assumes command state, and disables auto-answer when an on-to-off transition of DTR is detected

&D3 Modem resets and enters command state when an on-to-off transition of DTR is detected; note that initializing the modem recalls the user profile designated as the default for use on hard reset

When the modem is on-line, an on-to-off transition in the state of DTR persisting for less than the duration specified by the value in Register S25 is ignored. The factory setting for this register is 5/100 seconds. When **&D3** is selected, the modem will reset immediately on a change in DTR, regardless of the value in S25.

The effect of the **&D** command in synchronous communications depends on the mode selected. For information on the effect of DTR changes in synchronous modes, see Chapter 6, **Data Transmission Options**.

Data Set Ready (DSR) – &S

The DSR circuit (pin 6 of the RS-232C interface) indicates when the modem is connected to a communication channel and is ready.

In synchronous mode, when originating a call, DSR goes on when dialing is completed and an answer tone is detected from the remote modem. When answering a synchronous call, DSR goes on when the modem begins transmitting the answer tone.

In asynchronous or error-control mode, the **&S** command can be used to program the modem to keep DSR on at all times or have it operate according to the RS-232C specification described above.

&S0 DSR always on (factory setting)

&S1 DSR operates according to RS-232C specification

Request to Send/Clear to Send (RTS/CTS) – &R

The **&R** command establishes the relationship between the Request to Send signal issues from the DTE to the DCE (modem) and the Clear to Send signal sent by the DCE to the DTE. CTS indicates whether the modem is ready to accept data for transmission from the DTE. Its corresponding circuit, RTS (pin 4), puts the modem into a transmit mode (rather than a receive mode).

In asynchronous mode, the CTS circuit (pin 5) is on at all times in both the command state and the on-line state.

In error-control mode, the CTS circuit (pin 5) is on at all times in both the command state and the on-line state unless the **&K3** option (RTS/CTS flow-control) has been selected. If **&K3** is selected, the status of the **&R** command is ignored.

For synchronous operation, the modem must be programmed to leave CTS on in the on-line state and ignore RTS, or have CTS respond to an RTS off-to-on transition after a delay specified by Register S26.

&R0 CTS tracks RTS when the modem is on-line. In the command state, it ignores RTS (factory setting)

&R1 CTS remains ON while on-line and in the command state; RTS status is ignored

Note: If your DTE is designed to work with half-duplex modems, you can simulate half-duplex operation by programming an artificial Request-To-Send (RTS) to Clear-To-Send (CTS) delay with Register S26. Usually, a value of 2 (20 milliseconds) is adequate. The longer the RTS/CTS delay, the slower the data transfer.

DTE Flow-Control – &K

In error-control mode, the modem's buffers must hold incoming data until accurate transmission is verified. This process requires flow-control to prevent possible data loss resulting from buffer overflow. The methods for controlling the flow of data between the local DTE and the modem are selected with the **&K** command. These flow-control settings apply only when the modem is operating in error-control mode – configured with **&Q5** (see Chapter 6, **Data Transmission Options**).

&K0 Local flow-control disabled. This option should not be selected unless the local DTE provides end-to-end flow controls that guarantee data will not be lost (i.e., file transfer protocols).

&K3 RTS/CTS local flow-control (factory setting). This is the preferred method because it does not introduce transmission characters that cause file transfer overhead. However, this method requires that the RTS/CTS wires be present in the cable and that these RS-232C signals are passed between the modem and the DTE. Some computers do not support RTS and CTS signalling.

&K4 XON/XOFF flow-control (sometimes referred to as Stop/Start) with fixed values for XON and XOFF characters. XON is DC1 (ASCII); XOFF is DC3 (ASCII). This method should not be used if XON/XOFF characters are sent as data or file transfer protocol information.

&K5 Transparent XON/XOFF flow-control. This method provides a way to permit the XON/XOFF characters (DC1 and DC3) to be sent as data rather than interpreted as control characters. This method is supported in Hayes' communication software, Smartcom III.

Data Transmission Options

6

The V-series Smartmodem 2400 supports a wide range of transmission options. Data format, speed, and communication mode (asynchronous, synchronous, error-control) can be adjusted to suit the requirements for the communication environment or task. This chapter discusses each option, its relationship to the entire communication link, and the methods for implementing desired functions. Special features available in error-control mode are also discussed.

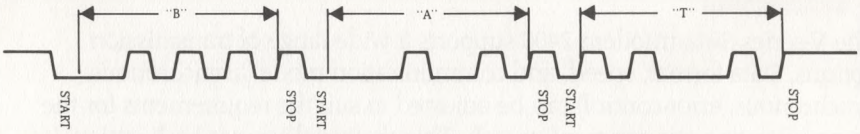
Data Formats

The structure of the data as it is transferred across the communication link may be in one of several formats. The capabilities of the two systems and the communication mode selected determine the formats available.

Asynchronous Transmissions

Most communication between PCs is asynchronous. Asynchronous transmissions pass data between the modems as characters. Data is transmitted as character plus parity bits framed by start and stop bits.

Asynchronous Data Stream



The use of parity bits is optional depending upon the asynchronous character format selected.

When receiving data the modem supports the following asynchronous character formats:

Start Bits	Data Bits	Parity	Stop Bits
1	7	even/odd	1, 2, or more
1	7	none	2
1	7	mark/space	1, 2, or more
1	8	none	1, 2, or more

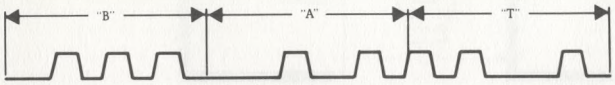
Although the modem can receive data with 1, 2, or more stop bits, when transmitting, the modem always generates data in a 10 bit format only (i.e., one stop bit only).

The modem automatically adopts the parity setting of the attached data terminal until the next AT command is received, or until the modem is turned off.

Synchronous Transmissions

Synchronous communication is a specialized form of data transmission and generally requires special hardware and software combinations. When operating in a synchronous mode, the modem functions as a pipeline, sending bits across the link between modems according to uniform blocks of time.

Synchronous Data Stream



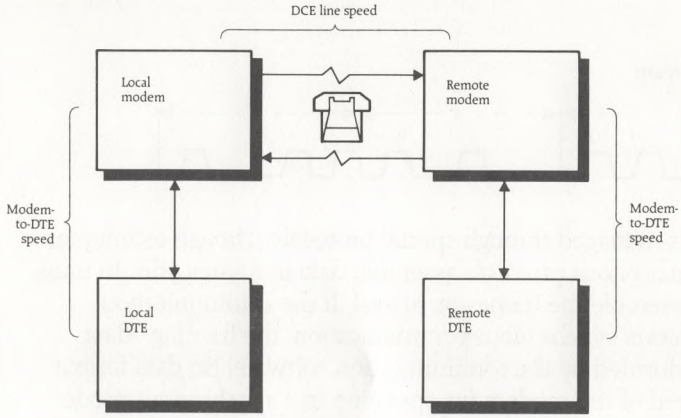
Communication is managed through special protocols. Though techniques differ slightly, synchronous protocols assemble data in frames prior to transmission and disassemble the frames on arrival. If the communication environment supports synchronous communication, the framing—data formatting—is performed by the communication software. No data format selection is required of the modem for operation in a synchronous mode.

Note: In error-control mode, transmissions can be either synchronous or asynchronous, depending upon the capabilities of the two communicating modems.

Speeds

Transmission speed is dependent upon the rate of transmission between the modem and the local DTE and the rate from the modem across the telephone link to the remote system.

Modem speeds



This diagram illustrates the speeds between the local DTE and the local mode, between the local modem and the remote modem, and between the remote modem and the remote DTE.

Modem to DTE speed

The rate of this connection determines the speed at which data is transferred between the modem and the DTE. Set up your communication software or terminal to talk to the modem at a range available to the modem. In error-control mode, the speed between the modem and the DTE can exceed the capabilities of the modem's DCE line speed. Adaptive compression and

buffering necessary in this mode permit communication between the modem and the DTE (receiving or sending) to be higher than the DCE (modem-to-modem) line speed. For optimum throughput in error-control mode, set the DTE speed to 4800 bps. Data can then be transmitted between the modem and the local DTE at 4800 bps while the compressed data is transferred across the line at 2400 bps.

In all other modes, the modem's rate is automatically detected and adjusted to match that of the DTE as each command is sent from the DTE to the modem (see Chapter 1, **AT Commands and Operating States**). **CONNECT XXXX** result codes reflect the rate of the connection between the local modem and the local DTE.

DCE Line Speed

The rate at which data is modulated (converted and transmitted) across the telephone connection varies according to the capability of the remote modem. Speed capabilities of the two modems determine the rate of this connection. Modulation handshake can be specified or negotiated according to a speed common to the two modems. The V-series Smartmodem 2400 supports speeds of 0-300 to 2400 bps. **CARRIER** result codes indicate the speed of this connection.

Maximum desired DCE line speed can be selected by writing to Register S37 and by selecting **N0**. The factory setting selects the speed of the last AT command issued as the desired DCE line speed. For example, if a maximum speed of 4800 bps is selected, the modem will use that as its highest rate. For more information, see **Register S37 — Desired DCE Line Speed**, in Appendix B, **V-series Smartmodem 2400 S-Registers**, and **Modulation Handshake** in Chapter 5, **Interface Parameters**.

The following table illustrates the possible speed combinations between two modems in a point-to-point configuration. Intersections of rows and columns indicate the transmission speed of the established connection.

bps	300	1200	2400
300	300	300	300*
1200	1200*	1200	1200
2400	1200*	1200	2400

* When a modem set to 1200 bps or 2400 bps calls another modem set to 1200 bps or 2400 bps speeds, the modems will connect at the lowest rate of the two. If one of the modems is set to 300 bps, both modems will modify their rates, moving up or down to 1200 bps.

These connection rates reflect possible speeds (with S37=0) when linking one 2400 bps modem to another 2400 bps or 1200 bps modem with **N1** selected (modulation handshake enabled).

Communication Modes – &M or &Q

The modem supports three communication modes: asynchronous, synchronous, and error-control (selected with the **&M** or **&Q** commands). The **&M** command with values 0-3 corresponds to the **&Q** command with the same values. However, **&M4** cannot be used in place of **&Q4**, nor **&M5** in place of **&Q5**.

The requirements of the communication link—including the software that addresses the modem and the capabilities of the local and remote modems—determines the mode used.

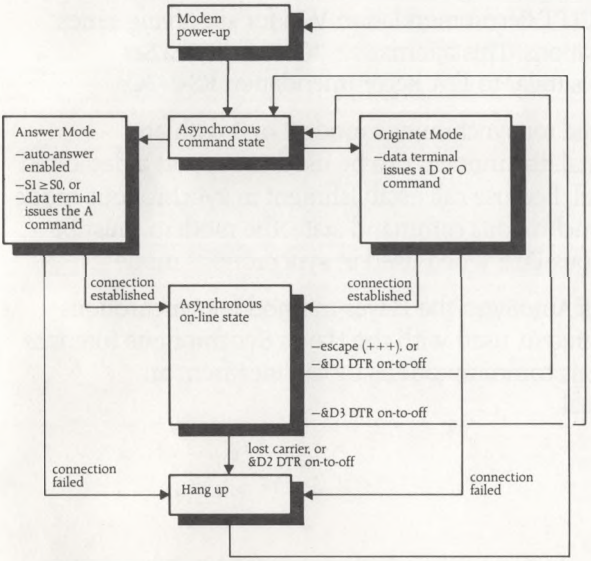
Most PC communications are performed in the asynchronous mode. If the modem is installed on a terminal, or computer with synchronous capability, connected to a mainframe, communication will most likely be synchronous. When communication is between two V-series modems, the error-control mode can also be selected.

Asynchronous Mode

In this mode, the modem operates asynchronously, transmitting characters to and from the local data terminal and across the telephone line. If another mode has been selected, asynchronous mode can be reselected with either the **&M0** or **&Q0** command. A complete explanation of communications in this mode is provided in Chapter 2, **Connecting with a Remote System**.

The diagram below illustrates how the modem operates in asynchronous mode.

Asynchronous Mode



The asynchronous mode supports both the on-line and the command states. When connected to an asynchronous data terminal, the modem can be configured, used as a dialer, and placed on-line for data communications.

Synchronous Modes

For those situations such as mainframe connections, the modem can be configured for synchronous modes. Synchronous communication requires special hardware in all but synchronous mode 4. In all modes, special software that provides the necessary synchronous protocol is required.

Asynchronous communications can be performed without regard to DTR signalling, but synchronous communication requires that the data terminal be able to exercise some degree of control over DTR. The responses to transitions on DTR specified by the **&D** command are overridden when the modem is operating in synchronous modes 2 and 3.

The modem's synchronous operating modes 1, 2, and 3 are based on the 108.1 application of the CCITT Recommendation V.24 for specifying series interchange circuit designations. This alternative, "Connect Data Set (modem) To Line," is very similar to EIA Recommendation RS-232C.

After it has been configured for synchronous mode 2 or 3 with an asynchronous data terminal, the modem can be used to support a dedicated synchronous data terminal. Because call establishment in synchronous mode 1 is initiated from the asynchronous command state, the modem must be attached to an asynchronous DTE when used in synchronous mode 1.

The modem also supports AutoSync, the Hayes method for synchronous communication. This technique, used with the Hayes Synchronous Interface (HSI), provides synchronous communications capabilities from an asynchronous data terminal.

Synchronous Mode 1: sync/async mode – &M1 or &Q1

Synchronous mode 1 is intended to support terminals capable of communicating synchronously or asynchronously over the same RS-232C port. In synchronous mode 1, a call is originated using asynchronous methods from the command state with the **D** or **A** command. The modem automatically switches to the synchronous on-line state when the **CONNECT XXXX** result code is delivered to the terminal.

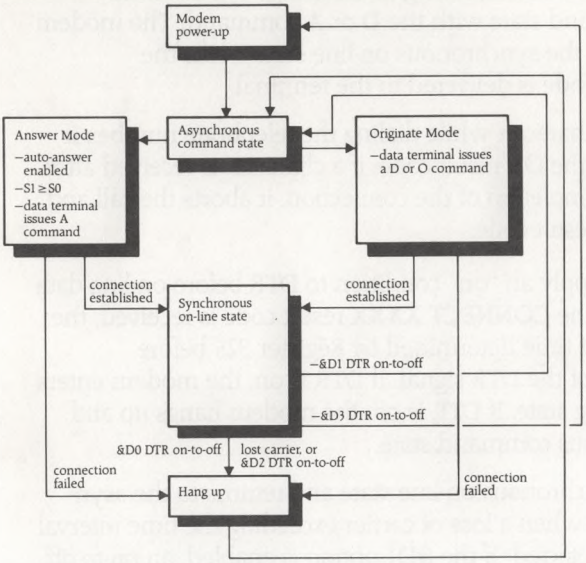
If the modem receives a character while dialing the telephone number, it aborts the call and sends the **OK** result code; if a character is received after dialing but prior to the completion of the connection, it aborts the call and sends the **NO CARRIER** result code.

The data terminal must apply an "on" condition to DTR before on-line data transfer can begin. Once the **CONNECT XXXX** result code is received, the modem delays a period of time determined by Register S25 before examining the condition of the DTR signal. If DTR is on, the modem enters the synchronous operating state. If DTR is off, the modem hangs up and returns to the asynchronous command state.

The modem exits the synchronous on-line state and returns to the asynchronous command state when a loss of carrier exceeding the time interval stored in Register S10 is detected. If the **&D1** option is enabled, an on-to-off transition of DTR causes the modem to return to the asynchronous command state without terminating the connection. If any other **&D** option is selected, the modem hangs up and returns to the asynchronous command state.

The diagram below illustrates how the modem operates in synchronous mode 1:

Synchronous Mode 1
"Sync/Async"



Synchronous Mode 2: stored number dial – &M2 or &Q2

In this mode, the modem supports a synchronous-only data terminal or computer with a synchronous adapter card. In synchronous mode 2, the modem automatically dials a number stored in location 0 (see the **&Zn=x** command) when the modem detects an off-to-on transition on DTR (when it is turned on). Once on-line, the modem hangs up and returns to the asynchronous command state when it detects an on-to-off transition of DTR exceeding the value set in S25.

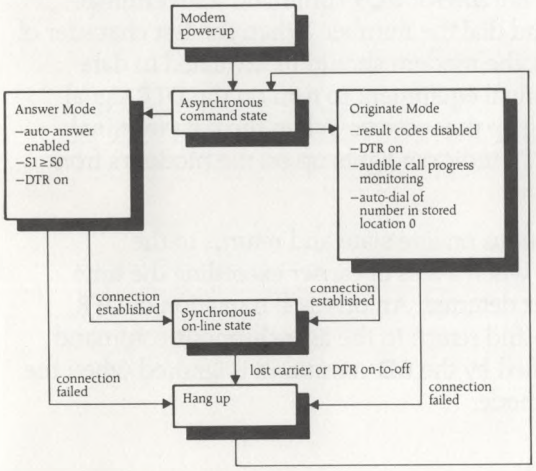
The modem exits the synchronous on-line state and returns to the asynchronous command state when a loss of carrier exceeding the time

interval stored in Register S10 is detected. An on-to-off transition of DTR causes the modem to hang up and return to the asynchronous command state. The DTR response specified by the **&D** command is ignored when the modem is configured for this mode.

Synchronous mode 2 is similar to the CCITT Recommendation V.25 bis ("Direct call and/or answer controlled by the DTE").

The diagram below illustrates how the modem operates in synchronous mode 2:

Synchronous Mode 2
"Stored Number Dial"



Note: Once this mode has been selected, the modem may go off-hook and begin dialing the stored number as soon as the modem is connected to the terminal. To prevent this, turn the modem off (place the power switch in the down position) before connecting the devices. When the connection is completed, turn the modem back on. For information on how to program this delay, see the description of **Register S25** in **Appendix B**. For information on the connection speed associated with a profile, see **Writing a Profile to Memory**, in Chapter 4, **Configuration**.

Synchronous Mode 3: manual dial with data/talk switch – &M3 or &Q3

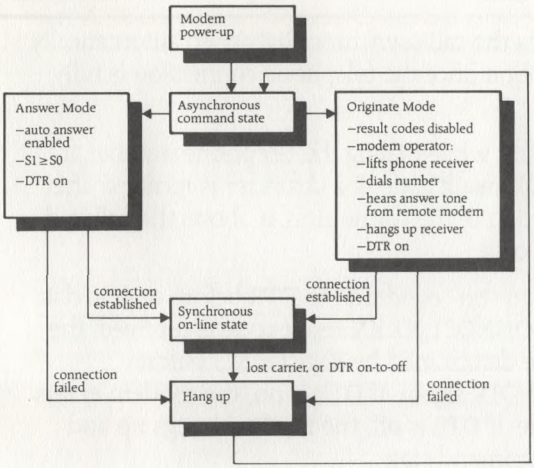
In synchronous mode 3, the DTR interchange circuit serves as a data/talk switch. This mode supports a synchronous-only data terminal or computer with a synchronous adapter card. A telephone must be attached to the jack labeled **TO PHONE** on the rear of the modem. This mode permits the data terminal operator to initiate a call using the handset with the modem in "talk mode," and to complete the call by switching the modem to the "data mode" by turning on the DTR interchange circuit.

To originate a call in synchronous mode 3, the DTR interchange circuit must be off. This places the modem in talk mode. When the modem has been configured for this mode with the **&M3** or **&Q3** command, the terminal operator can lift the receiver and dial the number. When the last character of the dial string has been dialed, the modem should be switched to data mode by causing the data terminal equipment to turn on the DTR signal. The operator should then hang up the receiver. When the data terminal equipment turns on DTR, the TR indicator lights up on the modem's front panel.

The modem exits the synchronous on-line state and returns to the asynchronous command state when a loss of carrier exceeding the time interval stored in Register S10 is detected. An on-to-off transition of DTR causes the modem to hang up and return to the asynchronous command state. The DTR response specified by the **&D** command is ignored when the modem is configured for this mode.

The diagram below illustrates how the modem operates in synchronous mode 3:

Synchronous Mode 3
"Manual Dial with Talk/Data Switch"



If the connection fails, the modem automatically hangs up and switches from data to talk mode. To reinitiate the call, DTR must again be turned off.

Synchronous Mode 4: AutoSync – &Q4

With communication software incorporating the Hayes Synchronous Interface (HSI), the modem can communicate synchronously without a synchronous interface adapter card.

In AutoSync, the modem places the call asynchronously then automatically switches to synchronous operation once the telephone connection is fully established.

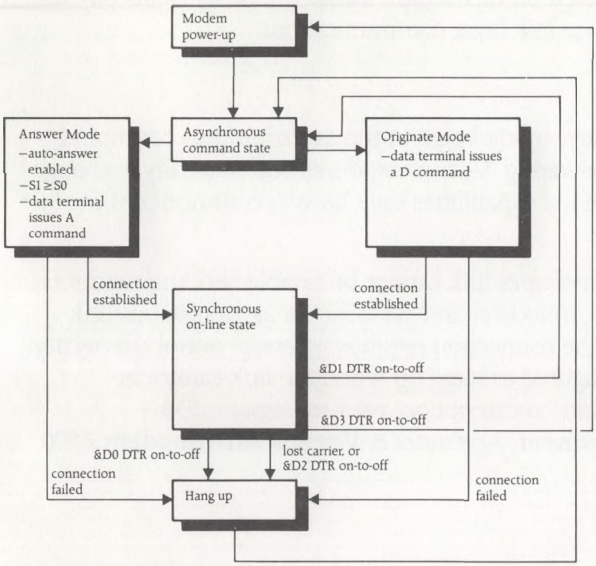
If the modem receives a character while dialing the telephone number, it aborts the call and sends the **OK** result code; if a character is received after dialing but prior to the completion of the connection, it aborts the call and sends the **NO CARRIER** result code.

The data terminal must apply an "on" condition to DTR before on-line data transfer can begin. Once the **CONNECT XXXX** result code is received, the modem delays a period of time determined by Register S25 before examining the condition of the DTR signal. If DTR is on, the modem enters the synchronous operating state. If DTR is off, the modem hangs up and returns to the asynchronous command state.

The modem exits the synchronous on-line state and returns to the asynchronous command state when a loss of carrier exceeding the time interval stored in Register S10 is detected. If the **&D1** option is enabled, an on-to-off transition of DTR causes the modem to return to the asynchronous command state without terminating the connection. If any other **&D** option is selected, the modem hangs up and returns to the asynchronous command state.

The diagram below illustrates how the modem operates in synchronous mode 4:

Synchronous Mode 4
Auto Sync



For more information on HSI, see the **Synchronous Applications Information** brochure accompanying this User's Guide.

Error-Control Mode

The error-control mode provides a means of controlling errors that may occur during transmission. When operating in this mode, the modem implements a protocol based on LAP-B (link access protocol—balanced), the CCITT recommendation for link layer communications.

Feature Negotiation

Connections in error-control mode begin in the asynchronous command state, either dialing or answering. V-series modems automatically exchange information to determine the capabilities they have in common and the framing technique to use.

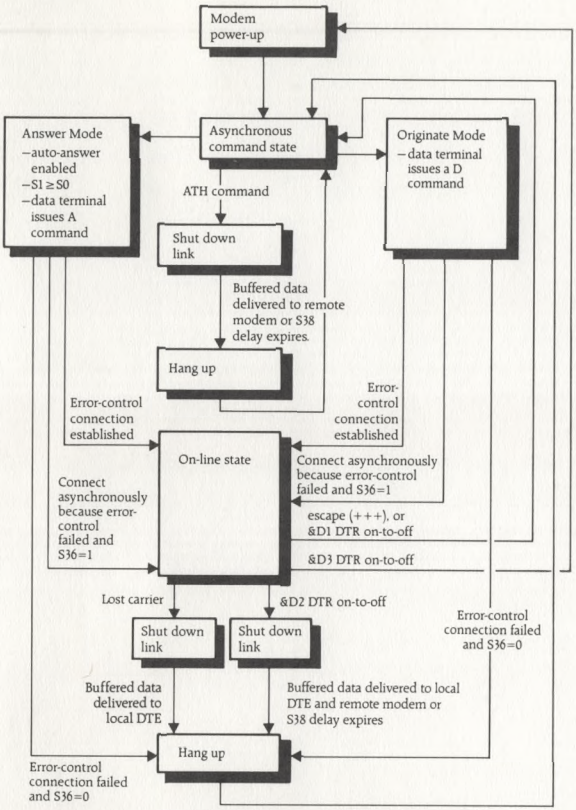
If for any reason the error-control link cannot be established, the modems attempt to complete the connection and establish an asynchronous link (**&Q0**). If the purpose of the connection requires an error-control connection, the modems can be configured to hang up when the link cannot be negotiated. For information on this option, refer to **Register S36 — Negotiation Failure Treatment**, Appendix B, **V-series Smartmodem 2400 S-Registers**.

Adaptive Compression

When data is transmitted (file transfer or interactive) adaptive compression is automatically enabled. The modem examines the data stream and encodes the data based on the frequency of a character's occurrence; this process reduces the number of bits required to transmit a block of data. The reverse process is performed by the receiving V-series modem, restoring the data to its original format. This technique effectively improves modem throughput by reducing the number of bits required to transmit a block of data. The extent to which adaptive compression enhances the effective throughput is based on the type of data transmitted.

The diagram below illustrates how the modem operates in error-control mode:

Error-control Mode


Modem power-up
Answer Mode
–auto-answer enabled
–S1 ≥ S0
–data terminal issues A command
Asynchronous command state
Originate Mode
–data terminal issues a D command
ATH command
Shut down link
Buffered data delivered to remote modem or S38 delay expires.
Hang up
Error-control connection established
Error-control connection established
On-line state
Connect asynchronously because error-control failed and S36=1
Connect asynchronously because error-control failed and S36=1
escape (+++), or &D1 DTR on-to-off
&D3 DTR on-to-off
Lost carrier
&D2 DTR on-to-off
Shut down link
Shut down link
Error-control connection failed and S36=0
Buffered data delivered to local DTE
Buffered data delivered to local DTE and remote modem or S38 delay expires
Hang up
Error-control connection failed and S36=0

Note: In error-control mode, the detection and generation of break signals at the DTE interface are in 10 millisecond increments: breaks not in even 10 millisecond intervals are rounded to the next increment. A break of less than 10 milliseconds may not be detected; a break longer than 2.55 seconds will be transmitted with a 2.55 second duration.

Error-control mode supports the asynchronous command state and the on-line state (synchronous or asynchronous). Transmission can be either synchronous or asynchronous, depending on the capabilities of the two connecting modems.

Appendix A
Hayes Standard AT Command Set

This appendix provides information about the Hayes Standard AT Command Set and its use with the V-series Smartmodem 2400. Also included is a chart that cross-references modem functions by command and DIP switch.

V-series Smartmodem 2400 Command Summary

The commands outlined below are used to configure and control the V-series Smartmodem 2400. Several commands and command options in addition to the Hayes Standard AT Command Set are also used by the modem. These are indicated by a dagger (†). Factory configuration for command options is indicated by boldfacing.

AT	command prefix – precedes command line
<CR>	carriage return character – terminates command line
A	go into answer mode; attempt to go to on-line state
A/	re-execute previous command line; not preceded with AT nor followed by <CR>
B0	select CCITT V.22 standard for 1200 bps communication
B1	select Bell 212A standard for 1200 bps communication
D	go into originate mode; dial number that follows; attempt to go to on-line state

In addition to specifying a number to dial, the following modifiers can be used with the **D** command:

0-9 # * A B C D	digits/characters for dialing
T	tone dial
P	pulse dial
W	wait for dial tone
,	delay processing of next character
@	wait for quiet answer (no dial tone transmitted)
!	hookflash
;	return to command state after dialing
R	reverse mode (for originating a call in answer mode)
S=n	dial number stored in location "n"

E0	disable character echo in command state
E1	enable character echo in command state
H0	go on hook (hang up)
H1	go off hook; operate auxiliary relay
I0	request product identification code
I1	perform checksum on firmware ROM; return checksum
I2	perform checksum on firmware ROM; returns **OK** or **ERROR** result codes
L0 or L1	low speaker volume
L2	medium speaker volume
L3	high speaker volume
M0	speaker off
M1	speaker on until carrier detected
M2	speaker always on
M3	speaker on until carrier detected, except during dialing
†N0	require modem to handshake at DCE speed selected with S37
†**N1**	permit modem to handshake at any DCE

O0	go to on-line state
O1	go to on-line state and initiate equalizer retrain at 2400 bps
Q0	modem returns result codes
Q1	modem does not return result codes
†Q2	modem returns result codes in originate mode, does not return result codes in answer mode
Sr=n	set register "r" to value "n"
Sr?	display value stored in register "r"
V0	display result codes in numeric form
V1	display result codes in verbose form
†W0	negotiation progress result codes not returned
†W1	negotiation progress result codes returned
X0	enable features represented by result codes 0-4
X1	enable features represented by result codes 0-5, 10-12
X2	enable features represented by result codes 0-6, 10-12
X3	enable features represented by result codes 0-5, 7, 10-12
X4	enable features represented by result codes 0-7, 10-12
Y0	disable long space disconnect
Y1	enable long space disconnect
Z0	reset modem and recall user profile 0
Z1	reset modem and recall user profile 1
&C0	assume data carrier always present
&C1	track presence of data carrier
&D0	ignore DTR signal
&D1	assume command state when an on-to-off transition of DTR occurs
&D2	hang up and assume command state when an on-to-off transition of DTR occurs
&D3	reset when an on-to-off transition of DTR occurs
&F	recall factory settings as active configuration

&G0	no guard tone
&G1	550 Hz guard tone
&G2	1800 Hz guard tone
&J0	RJ-11/RJ-41S/RJ-45S telco jack
&J1	RJ-12/RJ-13 telco jack
† &K0	local flow-control disabled
† &K3	RTS/CTS
† &K4	XON/XOFF
† &K5	transparent XON/XOFF
† &L0	dial-up line operation
† &L1	leased line operation
&P0	pulse dial make/break ratio = 39%/61%
&P1	pulse dial make/break ratio = 33%/67%
&Q0	asynchronous mode
&Q1	synchronous mode 1
&Q2	synchronous mode 2
&Q3	synchronous mode 3
&Q4	synchronous mode 4
† &Q5	error-control mode

Note: &Mn may be used in place of all &Qn options except &Q4 and &Q5.

&R0	track CTS according to RTS
&R1	ignore RTS; always assume presence of CTS
&S0	assume presence of DSR signal
&S1	track presence of DSR signal
&T0	terminate test in progress
&T1	initiate local analog loopback
&T3	initiate local digital loopback
&T4	grant request from remote modem for RDL
&T5	deny request from remote modem for RDL
&T6	initiate remote digital loopback
&T7	initiate remote digital loopback with self test
&T8	initiate local analog loopback with self test

&V	view active configuration, user profiles, and stored numbers
&W0	save storable parameters of active configuration as user profile 0
&W1	save storable parameters of active configuration as user profile 1
&X0	modem provides transmit clock signal
&X1	data terminal provides transmit clock signal
&X2	receive carrier provides transmit clock signal
&Y0	recall user profile 0 on power-up
&Y1	recall user profile 1 on power-up
&Zn=x	store phone number "x" in location "n"

The AT commands and the associated conditions described below may also affect modem configuration and operation.

C1	normal transmit carrier switching (preset)
F1	on-line state character echo disabled (preset)

These commands issued with parameters other than those specified will generate the **ERROR** result code.

Command/Switch Cross-Reference Table

The V-series Smartmodem 2400 is configurable entirely with commands issued from the keyboard; no DIP switches are necessary. However, if your software provides instructions for DIP switch settings, you will need to issue the appropriate commands to configure the modem. Refer to the table to cross reference command and DIP switches for any settings that may be required to set up your modem for use with your software.

Function	Smartmodem 1200	Smartmodem 1200B[1]	Smartmodem 1200B[2]	Smartmodem 2400 and V-series Smartmodem Families
DTR Status	**Switch1**	**Switch4**	**Switch4**	**Command**
Ignore DTR	Down	Down	Right	&D0
Follow DTR	Up	Up[3]	Left	&D1,&D2,&D3
Result Code Format	**Sw2/Cmd**	**Command**	**Command**	**Command**
Numeric	Down/V0	V0	V0	V0
Verbose	Up/V1	V1	V1	V1
Result Code Display	**Sw3/Cmd**	**Command**	**Command**	**Command**
Enabled	Down/Q0	Q0	Q0	Q0
Disabled	Up/Q1	Q1	Q1	Q1
Command State Echo	**Sw4/Cmd**	**Command**	**Command**	**Command**
Disabled	Down/E0	E0	E0	E0
Enabled	Up/E1	E1	E1	E1
Auto-Answer	**Switch5**	**Command**	**Command**	**Command**
Disabled	Down	S0=0	S0=0	S0=0
Enabled	Up	S0=1	S0=1	S0=1
Carrier Detect	**Switch6**	**Switch3**	**Switch3**	**Command**
Always True	Down	Up	Left	&C0
Follow CD	Up	Down	Right	&C1
Jack Type	**Switch7**	**Switch2**	**Switch2**	**Command**
RJ-12,RJ-13	Down	Down	Right	&J1
RJ-11,RJ-41S,RJ-45S	Up	Up	Left	&J0
Command Recognition	**Switch8**			**Dumb Strap**
Enabled	Down	Preset	Preset	rightmost pins[4]
Disabled	Up			leftmost pins
Communication Standard	**Sw9/Cmd**	**Sw5/Cmd**	**Command**	**Command**
CCITT V.22@1200 bps	Down/B0	Down/B0	B0	B0
Bell 212A@1200 bps	Up/B1[5]	Up/B1	B1	B1
Response to DTR on/off	**Switch10**			**Command**
Modem Reset	Down[6]			&D3
Go to Command State				&D1
Hang Up	Up[7]	Switch4 is Up[3]	Switch4 is Left	&D2
Port Selection	8	**Switch1**[9]	**Switch1**	**Ext Switch** [8]
COM1		Down	Right	Right
COM2		Up	Left	Left
Pulse Dial Ratio		**Switch6**		**Command**
39% Make/61% Break	Preset	Up[10]	Preset	&P0
33% Make/67% Break		Down		&P1

[1] Smartmodem 1200B full-card.
[2] Smartmodem 1200B half-card.
[3] Early versions preset to follow DTR. In a second version, coupling pins B-C of a status jumper causes the modem to ignore DTR; coupling pins A-B causes the modem to follow DTR.
[4] Internal modems preset for command recognition enabled.
[5] Early versions are preset with this parameter value.
[6] Early versions are preset with this parameter value.
[7] Early versions do not have this DIP Switch and will go to command state if Switch 1 is UP.
[8] Selected for external modems by physical port connection.
[9] Positions for this Switch in early versions are reversed.
[10] Early versions are preset with this parameter value.

When you have determined the appropriate command(s) required to configure your modem for use with your software, you can setup the modem and store the configuration as a user profile in nonvolatile memory. For example, the software's user manual may recommend that the Smartmodem 1200 be configured with DIP switches 1, 5, and 6 "up," and switch 4 "down." To set up the V-series Smartmodem 2400 with the corresponding configuration, you would start up the program, set the communication speed at 2400 bps, and enter the local mode (or the mode that permits you to issue commands to the modem). Then, you would type **AT&F&C1&D2S0=1E0&W** and press **<CR>**. This command line configures the modem for use with the software and stores the settings as user profile 0 in the modem's nonvolatile memory. For more information on creating and recalling user profiles see Chapter 4, **Configuration**.

V-series modems extend the range of options configurable on power-up or reset. For example, the V-series Smartmodem 2400 offers four flow-control settings. Unless you change the setting with the **&K** command, the modem will always power up with the factory-setting, RTS/CTS flow-control, enabled.

Note: No configuration is required if you are using Hayes' Smartcom III.

Appendix B
V-series Smartmodem 2400 S-Registers

The following descriptions provide definitions, parameters, and factory-set values for V-series Smartmodem 2400 S-Registers. These registers are used by the modem to hold configuration and operation parameters. Techniques for reading and writing to these registers are discussed in Chapter 4, **Configuration**.

Parameter values referred to as factory-set are those held in the modem's ROM as part of the modem's factory configuration. Setting an S-Register to a value outside the ranges specified is sometimes permitted, but not recommended.

Register S0 – Ring to Answer On

S0 sets the ring on which the modem automatically answers if the auto-answer mode is selected. Setting S0=0 disables auto-answer. The range for this register is 0-255 rings with a factory setting of 0.

Register S1 – Ring Count

The modem automatically tracks the number of times the phone rings, incrementing and writing the value in S1. The value of the register reverts to 0 if no ring occurs for an 8 second interval. The range for this register is 0-255 rings with a factory setting of 0.

Register S2 – Escape Sequence Character

S2 holds the ASCII value of the escape sequence character. The factory-set value is ASCII 43, the plus sign (+). The value for this register can be set to any value between 0 and 127. Setting S2 to a value greater than 127 disables the escape sequence; this prevents the modem from returning to the command state and disables command recognition.

Register S3 – Carriage Return Character

S3 holds the ASCII value of the carriage return (<**CR**>) character. The factory-set value is ASCII 13; the range for the register is 0-127. This character is used both as the command line terminator and the result code terminator.

Register S4 – Line Feed Character

S4 holds the ASCII value of the line feed character. The factory-set value is ASCII 10; the range for the register is 0-127.

Register S5 – Backspace Character

S5 holds the ASCII value of the backspace character. The factory-set value is ASCII 08; the range for the register is 0-32,127. This character is used for cursor movement to the left and to remove the previous character. As this value actually represents the combined operation of three characters (a backspace, a space, and another backspace), the time allotted to process this backspace character must not be any less than the time required by the modem to transmit three characters. For this reason, a repeat-key function may not operate properly on backspaces.

Register S6 – Wait Before Blind Dialing

The value in S6 determines how long the modem waits after picking up the telephone before it dials. This delay allows time for the central telephone office to detect the off-hook condition of the line and to apply a dial tone. The value in S6 is used when the **X0**, **X1**, or **X3** commands are in effect. **X2** and **X4** enable dial tone detection and disable blind dialing, making the value in S6 irrelevant. The factory setting for the register is 2 seconds; the register can be set to a value between 2 and 255 seconds.

Register S7 – Wait for Carrier after Dialing

The value in S7 determines the modem's time delay between dialing and responding to an incoming carrier signal after initial connection. If the modem does not detect a carrier within this time, the modem hangs up and returns the **NO CARRIER** result code. If the modem detects a carrier within the specified time, it goes on line. The factory setting is 30 seconds with a range of 1 to 255 seconds. This register sets the duration of the **W** dial modifier.

Register S8 – Duration of Delay for Comma Dial Modifier

S8 determines the duration of the delay generated by the comma (,) dial modifier. The factory-set value is 2 seconds; the range is 0 to 255 seconds.

Register S9 – Carrier Detect Response Time

S9 determines how many seconds a carrier signal must be present for the modem to recognize it and issue a carrier detect. This feature prevents a ring or a busy signal from being mistaken as a carrier. The value for the register is measured in tenths of a second. The factory setting is 6 (.6 second); the range is 1 (.1 second) to 255 (25.5 seconds).

Register S10 – Delay Between Lost Carrier and Hang Up

S10 specifies the time between loss of remote carrier and local modem disconnect. The delay permits the carrier to disappear momentarily without causing the modem to hang up. The value for the register is measured in tenths of a second. The factory setting is 14 (1.4 second); the range is 1 (.1 second) to 255 (25.5 seconds).

The modem recognizes a carrier after the period of time specified in Register S9. Therefore, if the value of Register S10 is less than that set for Register S9, even a momentary loss of carrier will cause the modem to disconnect.

Setting the register to 255 causes the modem to ignore actual carrier status and assume a carrier is always present.

Register S11 – DTMF Tone Duration

The value of S11 determines the duration and spacing of tones in Dual Tone Multifrequency (DTMF) dialing. The factory-set value is 95 milliseconds. The range is 50 milliseconds to 255 milliseconds. The value in this register has no effect on the speed of pulse dialing, which is fixed for 10 pulses per second.

Register S12 – Escape Sequence Guard Time

S12 holds the value of the delay required prior to and following the escape sequence. The guard time also dictates how quickly the escape sequence characters must be entered, since the interval between entry of each of the three characters must be of shorter duration than that specified for the guard time.

The factory-set value is one second; the range is 0 to 5.1 seconds (set in 20 millisecond increments from 0 to 255). If the guard time is set to 0, timing is not a factor.

Register S13–S15 – Reserved

Register S16 – Reserved for Modem Test Options

Register S17 – Reserved

Register S18 – Modem Test Timer

This register establishes the duration of the modem's diagnostic tests. When a test is active for a length of time equal to the value chosen for this register, the modem automatically terminates the test. A setting of zero (0) disables the test timer. The range for this register is 0-255 seconds with a factory setting of 0. The use of this register is explained fully in Chapter 3, **Troubleshooting**.

Registers S19–S24 – Reserved

Register S25 – DTR Detection

Register S25 serves two purposes. When the modem is operating in synchronous mode 1 or 4, the value assigned to S25 specifies the length of time the modem waits after a connection has been made, before examining the DTR circuit. This allows the modem to ignore an on-to-off transition of DTR and gives the user sufficient time to disconnect the modem from the asynchronous terminal to attach it to a synchronous terminal, without forcing the modem back to the asynchronous command state. During this time, the value for S25 is read in full seconds (e.g., the factory-set value of 5 equals 5 seconds, instead of .05 seconds).

In all other modes, and after call establishment in synchronous modes 1 and 4, the value is read in 1/100 seconds. In any mode, a change in DTR (on or off) that persists for a period shorter than the value held in S25 is ignored by the modem while it is on-line.

The range for this register is 0-255.

Register S26 – RTS to CTS Interval

This register is used to specify the interval to delay between an off-to-on transition on RTS and turning on CTS. This value takes effect when the **&R0** command option has been selected. This setting applies to synchronous modes 1, 2, and 3 only. The factory-set value is 1 (.01 seconds) with a range of 0-255.

Register S27–S35 – Reserved

Register S36 – Negotiation Failure Treatment

When an attempt to make an error-control connection fails, the modem reads this register to determine whether to terminate the connection, or to make an asynchronous connection (otherwise selected with **&Q0**). If S36 is set to 0, the modem hangs up; if S36 is set to 1, the modem attempts an asynchronous connection. This register is referenced only when the error-control mode has been selected with the **&Q5** command and this communication mode cannot be negotiated.

Register S37 – Desired DCE Line Speed

The modem attempts to connect with a remote modem at the highest supported DCE speed that does not exceed the value specified by this register.

S37=0	Attempt to connect at speed of last AT command issued (factory setting)
S37=1-3	Attempt to connect at 300 bps
S37=4	Reserved
S37=5	Attempt to connect at 1200 bps
S37=6	Attempt to connect at 2400 bps

If S37 is set to a speed higher than that supported by the modem, it will attempt to connect at its highest capability.

Register S38 – Delay Before Forced Hang up

This register specifies the delay between the modem's receipt of the command to hang up (or on-to-off transition of DTR if the modem is programmed to follow the signal) and the disconnect operation. This register is useful for error-control communications to ensure that data in modem buffers is sent before the connection is terminated. The factory setting is 20 (seconds). If this register is set between 0 and 254, the modem will wait that number of seconds for the remote modem to acknowledge all data in buffers before hanging up. If this timeout occurs before all data can be sent, the **NO CARRIER** (**3**) result code will be sent to indicate that data has been lost. If all data is transmitted prior to the timeout, the response to the **H0** command will be **OK**.

If S38 is set to 255, the modem does not timeout, and continues to attempt to deliver data in buffers until the connection is lost, or the data is delivered.

Appendix C
RS-232C Connections

This appendix provides RS-232C connector pin assignments and circuit descriptions of each signal.

RS-232C Pin Assignments

Pin Number	Circuit	Direction	Description
1	AA	N/A	Protective Ground
2	BA	To Modem	Transmit Data
3	BB	From Modem	Receive Data
4	CA	To Modem	Request To Send
5	CB	From Modem	Clear To Send
6	CC	From Modem	Data Set Ready
7	AB	N/A	Signal Ground
8	CF	From Modem	Data Carrier Detect
12	CI	From Modem	Select Alternate Rate*
15	DB	From Modem	Transmit Clock**
17	DD	From Modem	Receive Clock**
20	CD	To Modem	Data Terminal Ready
22	CE	From Modem	Ring Indicator
23	CI	From Modem	Select Alternate Rate*
24	DA	To Modem	Transmit Clock (DTE Source)

* CI is output on both pin 12 (Bell 212A assignment) and pin 23 (EIA RS-232C assignment).
** These signals are used for synchronous communication.

RS-232C Circuit Descriptions

Protective Ground (pin 1)
Grounds modem according to local regulations. The ground pin is electrically bonded to modem case.

TD – Transmit Data (pin 2)
Modem receives serial data from the local data terminal equipment on this pin.

RD – Receive Data (pin 3)
Modem transmits data to the local data terminal equipment on this pin.

RTS – Request To Send (pin 4)
Indicates whether the attached DTE is ready to receive data. When operating asynchronously, this circuit is always on, indicating that the modem can send at any time. The circuit functions in the same way in error-control mode, unless the RTS/CTS flow-control is selected; then the modem uses this signal to determine when the DTE is ready to receive data. In synchronous, on-line operation (where supported), the modem can be programmed to ignore RTS or respond to RTS by turning on CTS after the delay specified by Register S26. This is controlled with the **&R** command. When in command state, modem always ignores RTS.

CTS – Clear To Send (pin 5)
Indicates whether modem is ready to accept data, from a terminal or a computer, for transmission. When operating asynchronously, this circuit is always on, indicating that the modem can receive data at any time. In error-control mode, the signal is maintained on unless RTS/CTS flow-control is selected; then, the modem uses this signal to indicate to the DTE when the modem is ready to receive data. When operating synchronously (where supported), but in the asynchronous command state, the modem also maintains the CTS signal on. The modem turns CTS off immediately upon going off-hook, and maintains CTS off until both DSR and DCD are on and the modem is fully prepared to transmit and receive synchronous data. The modem can also be programmed to turn CTS on in response to an off-to-on transition of RTS (see discussion of **&R** command).

DSR – Data Set Ready (pin 6)
Indicates whether modem is connected to a communication channel and is ready to exchange control characters to initiate data transmission. In asynchronous or error-control mode, the modem can be programmed to maintain DSR on at all times or to cause DSR to operate in accordance with EIA RS-232C specification. In synchronous mode, DSR always operates according to RS-232C specification. (See discussion of **&S** command).

Signal Ground (pin 7)
Common reference for all signals on connector.

DCD – Data Carrier Detect (pin 8)
Indicates whether the receiver section of the modem is or is not accepting transmitted data. In asynchronous or error-control mode, the modem can be configured to maintain DCD on at all times, or to track the presence of a data carrier from the remote modem. In synchronous mode, this signal tracks the presence of a data carrier from a remote modem. See the discussion of the **&C** command.

Alternate Rate Select (pins 12 and 23)
The modem turns on this signal to indicate selection of the current line speed.

TxC – Transmit Signal Element Timing (pin 15)
Provides the transmitting section of the modem with timing information. Synchronizes the local modem transmitter and the remote modem receiver. Regardless of the source, TxC is applied by the modem to pin 15 of the RS-232C connector and is used by the data terminal equipment to time the transmission of serial data on the TD (Transmit Data) circuit. This signal pertains to synchronous communications only. Modem can be programmed to source this signal, or to derive it from either the data terminal equipment (pin 24), or from the receive carrier (slave operation). See discussion of the **&X** command.

RxC – Receive Signal Element Timing (pin 17)
Provides the receiver section of the modem with timing information. Modem always derives this signal from the receive carrier, and applies it to pin 17; this signal is used by the data terminal to time the incoming bit stream from the local modem (RD – Receive Data – pin 3). This signal pertains to synchronous communications only.

DTR – Data Terminal Ready (pin 20)
Prepares and maintains the connection to a remote system. The modem can be configured for a variety of responses to DTR signal, as required for the communication mode. See discussions of communication modes and **&D** command.

RI – Ring Indicator (pin 22)
Carries signal to indicate the modem is receiving call signals (ring/tones). The modem turns on this signal whenever an incoming ring is detected.

Transmit Clock Source (pin 24)
If the data terminal equipment sources the transmit signal element timing on this pin, the modem can be programmed to use this clock signal rather than its own internal clock. This signal pertains to synchronous communications only. See discussion of the **&X** command.

Appendix D
Specifications

This appendix summarizes the modem's operational and physical specifications.

Communication Modes

Asynchronous, synchronous, and error-control

Communication Rates and Communication Standards Supported

0-300 bps	Bell 103
1200 bps	Bell 212A
1200 bps	CCITT V.22
2400 bps	CCITT V.22 bis

Automatic Speed Adjustment on Initial Handshake

Fallback from 2400 bps to 1200 bps, 300 bps

Error Control

Implementation of LAP-B at 1200 bps and 2400 bps

Operation

Full-duplex at 2400 bps and below

Feature Negotiation

Automatic recognition of remote V-series modem for exchange of connection capabilities

Flow-Control

None, RTS/CTS, XON/XOFF (Stop/Start), Transparent XON/XOFF

Adaptive Compression

On-line compression of data for enhanced throughput in error-control mode at line speeds of 2400 and 1200 bps

Call Progress Monitoring

Recognizes dial tone, ringback signal, and busy signal

Dialing Capability

Command-selectable tone or pulse dialing. Tone duration and spacing variable from 50 to 255 msec

Command Buffer

255 characters

Memory

User-modifiable, nonvolatile memory stores up to four, 36-digit telephone numbers and two user profiles (in addition to the active configuration held in RAM and the factory configuration stored in ROM)

Line Type

Two-wire, dial-up and conditioned leased line operation

Echo Suppressor Defeat Tones

Bell standard: 2225 Hz +/- 10 Hz CCITT standard: 2100 Hz +/- 15 Hz

Receive Signal Frequency Tolerance

+/- 7 Hz

Status Indicators

Eight LED indicators on front panel

Interface Connectors

On rear panel: two modular telephone jacks; one RS-232C female connector (DB-25S); one female Hayes power supply connector; on-off switch.

Audio Monitor

Two-inch speaker with programmable volume control

Power Supply

U.L.-listed 120 V ac, 60 Hz input; 14 V ac output. Rectified, filtered, and regulated inside the modem

Power Consumption

6.5 watts

Registration

FCC Part 68 and Part 15 (sub-part J, section B) approved

Enclosure

4.4 cm x 13.97 cm x 24.38 cm (1.75 in x 5.5 in x 9.6 in)

Glossary

adaptive compression
A Hayes-developed technique for coding data that reduces the number of bits and the amount of time required to transmit data, thereby transmitting more data in a given amount of time. Adaptive compression adjusts to the type of data being transmitted. Transparent to the user, adaptive compression is automatically enabled when the modem is in error-control mode (**&Q5**).

address
A label, name, or number that identifies a particular register or an external storage location in main memory. Also, to store data in, or retrieve it from, a specific location in memory.

ARQ protocol
(ARQ, automatic request for repeat) A form of error control for data transmission in which the receiving device can detect a transmission error and automatically transmit a request-repeat signal to the transmitting device. The transmitting device then retransmits the corrupted data until it is either received correctly or it persists beyond a predetermined number of repeated transmissions.

ASCII
American Standard Code for Information Interchange. A seven-bit-plus-parity code established by the American National Standards Institute to achieve compatibility between data services.

asynchronous communication
Communication of data in which time intervals between transmitted characters may be of unequal length. Transmission is controlled by start and stop elements at the beginning and end of each character. (Compare "synchronous communication.")

asynchronous framing technique (AFT)
Hayes-developed framing technique which provides synchronous-like transmission across an asynchronous link. Synchronous protocols assemble data in frames prior to transmission and disassemble the frames on arrival.

AutoSync
Hayes method of synchronous transmission built into the modem firmware, enabling universal compatibility between synchronous hardware and software. To use AutoSync, the software program used with the modem must implement the Hayes Synchronous Interface (HSI) using the Hayes Synchronous Driver (HSD).

baud
A unit for measuring the speed of data transmission: for example, a device that transmits 300 bits per second also transmits at 300 baud. Technically, baud refers to the number of times the condition of the communications line changes each second.

Baud and bps (bits per second) are often incorrectly used interchangeably. Baud is the same as bps only if each signal of information being conveyed over the communications line represents one bit. Baud for 2400 bps and 1200 bps transmissions are both 600 although the actual throughput is different.

Bell-compatible
A term indicating that the audio tones issued by the modem meet Bell Telephone standards. Variants of the term include Bell 103-compatible (a standard for 300 bps modems) and Bell 212A-compatible (a standard for 1200 bps modems).

bit
Acronym for binary digit, the smallest unit of information stored in the computer. Other units of storage include eight bits together – called a "byte," and four bits together – called a "nibble."

bps
Abbreviation for "bits per second," a measurement of the number of bits transmitted per second.

break signal
Interruption of normal execution to allow for manual or software intervention. Effected by a string of data (zeros) transmitted longer than the time it takes to transmit one ordinary character.

buffer
An area of storage used to temporarily hold data being transferred from one device to another. A buffer is used to compensate for the different rates at which hardware devices process data.

In communications, buffers are most often used to capture incoming data. Buffers can be opened and closed from the keyboard, or emptied to make room for more information. To save the contents of a buffer, you may record them to disk or send them to the printer. Typically, the buffer and its contents disappear when power is shut off.

byte
An information unit used to represent one alphanumeric character, and usually composed of eight bits (a byte may consist of more or fewer bits, depending on the model of the computer).

carrier signal
A continuous frequency sent out by the modem, capable of being altered to carry data. This is the signal a modem looks for before it begins to send data.

CCITT
Comite Consultatif Internationale de Telegraphie et Telephonie. An international consultative committee that sets international communications usage standards between countries (e.g., CCITT V.24 is a set of standards specifying the characteristics for interfaces, including descriptions of the various pin assignments: similar in structure to the EIA's RS-232C standards).

character format
In communications, the settings that establish an agreement between two computers on how they will communicate. Settings are controlled by the software and may include bps, duplex, parity, character length, and the number of stop bits.

Clear to Send (CTS)
A pin on an interface for the modem indicating whether the modem is ready to accept data, from a terminal or computer, for transmission (one of the interface standards used by RS-232C).

clock
In synchronous devices, a circuit that sends out signals at precise frequencies to schedule the operation of the device: each operation taking a specified number of signals, allowing the controlling unit to initiate the proper operation at the correct time.

command line
A string of commands entered on a single line, usually beginning with **AT** and ending with **<CR>**. Commands entered on the command line can be interspersed in any order that is not illogical (e.g., the **A**, or answer, command cannot be used before a phone number).

command state
The mode of operation in which the modem responds to commands instead of exchanging data with another modem. (Compare "on-line state.")

command state character echo
Transmission of characters from your computer to your display when in the command state. Turn character echo on or off (**E0** or **E1**) to see what you type during the command state.

command syntax
The "grammar" that defines command format and enables the modem to interpret commands correctly.

communication environment
An environment dedicated to the transfer of information between persons and equipment. Usually comprised of individual communication equipment, terminal equipment, networks, transmission systems, etc., capable of interconnection and interoperation to form an integrated system. In a communication environment, the individual components serve a common purpose, are technically compatible, function according to common and compatible principles of operation, and employ and respond to some form of data transmission control.

communication link
The entire communication interchange between two modems, including the phone line, the switchboard connection, and any connectors and cables installed at users' workstations.

communication software
The computer program containing the instructions your machine needs to communicate. As with all software products, communication software is available in both minimal and full-featured versions.

communication standard
A set of rules for data exchange, usually corresponding to a particular speed. For example, CCITT V.22 is a standard used for 1200 bps comunication.

configuration
The values assigned to parameters defining how the modem operates and its interface to the attached computer or other device (e.g., printer). See "factory settings."

Data Carrier Detect (DCD)
A pin on the modem's interface that indicates whether the receiver section of the modem is or is not receiving transmitted data. A standard interface used by RS-232C and CCITT V.24.

Data communication equipment (DCE)
The equipment providing the functions necessary to establish, maintain, and terminate the connection, the signal conversion, and the coding required for communication between two devices. A modem is DCE; a PC is DTE. (Compare "DTE.")

data compaction
The reduction of space, cost, and time for the generation, transmission, and storage of data without loss of information, by using transmission techniques designed to eliminate redundancy, remove irrelevancy, and use special coding.

data compression
Eliminating blanks, unnecessary fields, and redundant data from various records, or reducing the length of a message required to transfer a given amount of information, in order to reduce the amount of storage required to store a given amount of data.

Data Set Ready (DSR)
A pin on the modem's interface that indicates whether the modem is connected to a communication channel and is ready to exchange control characters to begin data transmission. A standard used by RS-232C and CCITT V.24.

data stream
The data transferred in a single read or write operation.

Data terminal equipment (DTE)
The equipment needed to support the transmission of data from the data sink (receiving device) and/or the data source (originating device). (Compare "DCE.")

Data Terminal Ready (DTR)
A pin on the modem's interface that prepares and maintains the connection to a communication channel. A standard used by RS-232C and CCITT V.24.

DB-25 connector
A connector, available in male and female "genders" (the DB-25P and the DB-25S), that specifies pin numbers. The pin-to-port connection enables the modem to communicate information to the PC. Modems and serial ports of most computers have female connectors.

default
A setting used when none is specified; can be a factory-set value, or one entered by the user to be in effect on power-up or reset.

dial string
Combination of alphanumeric characters and dial modifiers used with the dial (**D**) command.

dial-up line
A communication line that connects a terminal and the computer when a specific number is dialed. Data is then transmitted over various telephone lines to the computer, and the person dialing is usually charged for the length of connect time.

display
The computer's monitor, or VDT. In communications, the local or the remote modem must echo characters to the display for you to see them. Even if you cannot see these characters, they are being processed by the computer.

DTE flow-control
Flow-control managed by the data terminal equipment (DTE). The DTE serves as the device receiving and responding to data transmitted by the data source, allowing data communication control to be performed in accordance with link protocol.

dumb mode
A mode of operation which provides only for the input and output of data to and from the computer, disabling all other programming functions.

EIA
Electronic Industries Association. An organization of electronics manufacturers that sets standards for the electrical and functional characteristics of equipment used in data communications.

equalizer retrain sequence
Frequency conditioning that improves a line in order to reduce the amount of interference and attenuation occurring during data transmission. Attenuation, a reduction in signal amplitude, is caused by resistance in the communication line and may cause loss of data.

error-control
A process that detects errors in the transmission of messages, requests the retransmission of faulty messages, and accepts correct messages: error control is handled by the particular protocol of the communication system (see "ARQ protocol" and "LAP-B protocol").

escape sequence
A sequence of three characters that causes the modem to interrupt on-line processing and exit to the command state while remaining connected to the remote system. The escape sequence indicates that subsequent characters are to be interpreted differently, as control characters instead of as data.

factory settings
The set of parameter values defined at the factory and stored in ROM that determine the modem's operating characteristics. A copy of this set of values can be modified and saved in nonvolatile memory for later use. (See "configuration.")

feature negotiation
Capability of the V-series Smartmodem 2400, to automatically distinguish between V-series modems and other Hayes (or 100% Hayes-compatible) modems once a connection has been established. Options allow you to specify guidelines for the modem to follow when setting up communications with remote systems.

firmware memory
Instructions or information built into the circuitry of a device's ROM (read only memory), that determine its operating characteristics, and that cannot be altered.

flow control
A control of the rate at which data is transmitted from one location so that it is equal to the rate at which it can be received or buffered at another location.

forward error-correction
A system of error control where the receiving device can detect and correct characters or blocks that contain a predetermined number of error bits. Error correction is accomplished by adding error-detection and error-correction bits to each transmitted character or block using Trellis encoding and Viterbi decoding.

four-wire circuit
A two-wire circuit that uses two paths arranged so that the signals in the circuit are transmitted in one direction only by one path and in the other direction only by the other path.

framing
The communication process that determines which group of bits (frame or block) constitutes a character and which group of characters represents a message. Framing is handled by the protocol (format and timing) of the communication system.

full-duplex
A communications setting that enables you to send and receive information simultaneously, as from a terminal to the computer and from the computer to the terminal.

guard time
The guard time precedes and follows the escape sequence, to prevent the modem from interpreting data as the escape sequence. The factory-set guard time is 1 second. The guard time may be changed by writing another value to the S12 register.

half-duplex
A communications setting in which data can travel in only one direction at a time, as from a terminal to the computer or from the computer to the terminal. A special signal must be sent at the end of each transmission to tell the receiving device that it is free to transmit.

handshaking
The exchange of control characters between an input/output device and an I/O interface. The characters indicate that the device is ready to receive data, that the data has been sent, and that the data has been accepted.

hard reset
See "reset."

hybrid
A device or circuit consisting of two or more components, each normally used in a different application and not usually combined to meet a particular requirement. For example, a hybrid may be an electronic circuit that has both analog and digital capability.

interface
The means of interaction between two devices or systems that handle data in different ways, such as in different codes or formats. A shared boundary between two devices, systems, or programs, enabling interconnection or interoperation between the two.

key phone system
A phone system with multiple extensions, usually with a display that designates when an extension is in use.

LAP-B
(Link Access Protocol-Balanced) When the modem is configured to operate in error-control mode, the modem implements the LAP-B protocol, which is based on the CCITT recommendation for link layer communications. LAP-B utilizes ARQ protocol to detect and correct data transmission errors. The V-series Smartmodem 2400 uses LAP-B at 1200 bps and 2400 bps.

leased line
A permanent communication line between a computer and a terminal that provides private, full-time access to the connection by a subscriber for a fixed fee. (Compare "dial-up line.")

link layer
The group of related functions, procedures, and protocols needed to establish, and maintain connections between the data stations of a communication network.

long space disconnect
A continuous break signal transmitted by the local modem for 4 seconds, after receiving a break signal from the remote modem, and prior to disconnecting from the remote modem.

loopback tests
Refers to a type of test in which signals are looped from a test center through a data set or loopback switch and back to the test center for measurement.

make/break pulse dial ratio
In pulse dialing, controls the ratio of the off-hook (make connection) to on-hook (break connection).

modulation handshake
Handshake that takes place between the remote and local modems if the speeds of the two modems differ. The V-series Smartmodem 2400 is factory-set to attempt to make a connection by falling back or rising up to the speed of the remote modem.

modulation line
The communication line which changes digital signals to analog signals.

negotiation failure treatment
The modem's Register S36 provides negotiation failure treatment. When an attempt to make an error-control connection fails, the modem reads the value in Register S36 to determine whether to terminate the connection, or to make an asynchronous connection (otherwise selected with the **&Q0** command).

If S36 is set to 0, the modem hangs up; if S36 is set to 1, the modem attempts an asynchronous connection. This register is referenced only when the error-control mode has been selected with the **&Q5** command; this communication mode cannot be negotiated.

nonvolatile memory
Memory that retains data when the power supply is disconnected or when the modem is otherwise reset. (Compare "volatile memory.")

null modem cable
A cable designed to connect two computers via the serial ports that are ordinarily connected to a modem. A null modem cable "fools" each system into thinking that it is actually talking to a modem instead of another computer.

on-line character echo
Transmission of characters from the remote computer to the local display when in the on-line state.

on-line state
The mode of operation in which the modem is communicating with a remote computer. (Compare "command state.")

originate-only modem
Modem capable of originating calls only, and transmitting data in one direction only. This type of transmission is rarely used in data communication systems since it is necessary for the computer to respond that the transmitted data has been received.

parallel transmission
Method of data transfer in which all bits of a character or byte are transmitted simultaneously either over separate communication lines or on different carrier frequencies on the same communication line. Parallel transmission is faster than serial transmission but requires more lines between sending and receiving locations.

parameter
A communications setting whose value determines the characteristic or behavior of a particular operating feature. The modem's configuration profiles are comprised of a set of specific parameters with specific values.

parity
A form of error checking. Systems can be set to odd, even, or no parity. Odd parity causes the system to add the 1s and 0s of the seven bits used to transmit a character, then adds an eighth bit. If the sum of the seven bits is even, the system adds a 1 to make it odd; if the sum is odd, the system adds a 0 to remain odd. Even parity works the same way. No parity causes the system to transmit characters in the standard ASCII code set; the eighth bit is transmitted, but ignored by both communication systems.

point-to-point communication
(1) A network configuration in which a connection is established between two, and only two, terminal installations. The connection may include switching facilities.

(2) A circuit connecting two points without the use of an intermediate terminal or computer.

port
A connection between the CPU and another device (e.g., modem), through which data can enter or leave the computer or be transferred between the CPU and memory.

private line
In telephone systems, an arrangement in which a user's end- instrument (e.g., telephone) or set of end-instruments, is connected to a single and separate local loop (communication channel between switching channel and end-instrument). Thus each instrument (or set of instruments) has a distinct number assigned to the tone user. There are no other users' end-instruments connected to that loop or assigned to that number. Privacy is complete, except perhaps for accidental cross-talking or a faulty connection.

protocol
A formal set of conventions governing the format and relative timing of message exchange between two communicating systems. The means used to control the orderly communication of information between stations in a communication link.

pulse dialing
A method of dialing using pulse-generated frequencies (e.g., rotary dialed telephones).

register
A memory location for operating parameters. (See "S-Registers.")

Request to Send (RTS)
A pin on the modem's interface that puts the modem into a transmit mode of operation rather than a receive mode. A standard used by RS-232C and CCITT V.24.

reset (hard)
A power-up; replaces all changes to the modem's configuration with the factory-set values, or values specified to be recalled on power-up.

reset (soft)
A software-controlled command (Z) that performs a reset without power interruption, and recalls either of two user profiles.

result code
A screen message from the modem to indicate the result of a command or the progress of a call.

RS-232C
The Electronics Industry Association (EIA) standard for 25-pin serial interfaces and the signals applied to the various pins.

RTS/CTS flow-control
The transmission of data controlled by the RTS and CTS signals of two communicating devices. The RTS signal is generated by the receiving device in order to condition a remote transmitter to begin data transmission. The CTS signal is generated by the transmitting device to indicate that it is ready to transmit data.

S-Register
Smartmodem register. Memory locations, each capable of storing one byte, where the modem stores parameters, counters, timing values, and other operating information.

serial transmission
A method of transmission in which each bit of information is sent sequentially, one bit at a time or one byte at a time, over a single line rather than simultaneously as in parallel transmission.

shielded cable
A cable with a single conductor or pair of conductors in which the insulated conductor(s) is (are) enclosed within a metallic web that may be grounded.

soft reset
See "reset."

start bit
In asynchronous communications, a start bit is transmitted at the beginning of each character to notify the receiving system that the next seven or eight bits will contain information. (Compare "stop bit.")

stop bit
In asynchronous communications, one or two stop bits are transmitted at the end of each character to tell the receiving system that the whole character has been sent and to prepare it for the next start bit.

synchronous communication
Communication method by which bits are transmitted and received at a fixed rate, with the transmitter and receiver synchronized. This eliminates the need for start-stop elements, thereby providing greater efficiency. Used to transmit large blocks of data over special communications lines. (Compare "asynchronous communication.")

synchronous framing technique
Synchronous protocols assemble data in frames prior to transmission and disassemble the frames on arrival.

synchronous terminal
A device that transmits signals at regular, timed intervals to the system with which it is communicating.

terminal mode
When communicating with a large computer, your machine must appear to the mainframe as merely one of its own terminals. Communication software creates this illusion or "emulation." When the modem is communicating with a remote system, it is in terminal mode.

terminal emulation program
Software that allows characters typed on a computer keyboard to be sent directly to another device. Sometimes called dumb terminal emulation.

throughput
The amount of processing performed in a given amount of time by a computer or computer component.

tone dialing
(Also referred to as Touch-tone dialing.) A method of dialing which uses multiple tone signaling.

transmit clock
In synchronous communication, the transmit clock is a circuit that sends out signals at precise frequencies to schedule the operation of the computer. Each operation takes a specified number of signals, and then the controlling unit can initiate the proper operations at the correct intervals.

Transmit Signal Element Timing
In synchronous communication, the synchronization of the local modem transmitter and the remote modem receiver, in which the signal element provides the transmitting section of the modem with timing information.

two-wire circuit
A circuit in which one line or channel is used for communication in both directions. (Compare "four-wire circuit.")

UART
Universal Asynchronous Receiver/Transmitter. An integrated circuit in your computer's serial port or on its serial card, that performs the parallel-to-serial conversion of digital data that is to be transmitted and the serial-to-parallel conversion of digital data that has been transmitted (e.g., a UART converts the outgoing digital data in parallel format from a microcomputer into the serial format accepted by the modem).

XON/XOFF flow-control
A standard protocol used by devices receiving data, consisting of two signals: ready to receive, and not ready to receive. This protocol is usually built into the communication software, and in most cases you will not be aware that the signals are being sent and received. However, you can stop or start the on-screen scroll of information when accessing most databases. X-ON is generated by entering a Control-Q, and X-OFF by entering a Control-S (also referred to as Stop/Start flow-control).

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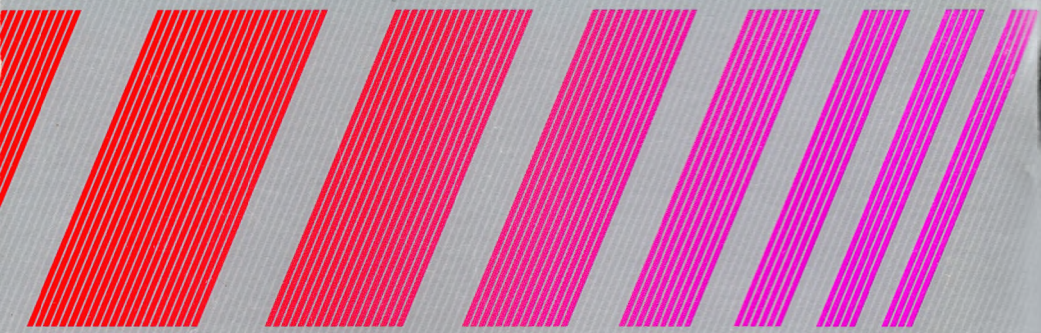

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